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SOME OBSERVATIONS ON THE EARLY MANAGEMENT OF GUNSHOT WOUNDS OF THE ARTERIES.[1]

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MUCH has been written about arterial injuries by those working at special vascular centres; little has been written by those who have had to deal with the battle casualty in the field. We hope that it will be a long time before warfare brings the problems of vascular surgery into prominence again, but the present is an appropriate time to review them in a true perspective. The observations on which this paper is based were mostly made during a period of nine months with forward surgical teams in New Guinea and at two landings in the Dutch East Indies, and during a further period of fourteen months with advanced general hospitals in the same areas.

THE PATHOLOGY OF ARTERIAL INJURY.

The "Near Miss".

After a high-velocity projectile has passed close to an artery the vessel may sometimes be seen to be in spasm without having any visible organic damage in its walls. Such a condition was described by surgeons of the 1914-1918 war, and came to be known as *"stupeur arterielle"* or "Kroh's arterial spasm". Such spasm may cause impairment of the distal pulse in that limb.[(3)]

The Contused Artery.

The contused vessel, when exposed, is seen to have a patch of bruising in its wall. The intima may be partly ruptured and there may or may not be a thrombus present in the lumen. There is nearly always some arterial spasm present. There is no primary bleeding from the injured vessel, but if the wound becomes septic, secondary hæmorrhage is probable. Also, traumatic false aneurysm may follow such an injury.

The Partially Divided Artery.

In the partially divided vessel there is a lateral opening involving a certain fraction of its circumference. Visible arterial spasm often affects the vessel concerned and may also affect the collateral arteries. That it can affect the collateral vessels has been denied by Cohen,[(7)] who regards the arterial spasm which follows a gunshot wound as being much more limited than that which follows other injuries, and states "segmental (military)

[1] Accepted for publication on March 6, 1947.

spasm is regarded as innocuous". Maybury[15] states that arterial spasm is not commonly produced by gunshot wounds. Elkins,[9] however, holds that in the vascular injuries of warfare segmental spasm may reflexly involve collateral vessels.

That widespread arterial spasm can occur with gunshot wounds and can, by affecting the collaterals, impair the distal circulation in the limb was first impressed on me by the following case.

A soldier, aged twenty-two years, was seen nine hours after receiving wounds of the left arm, abdominal wall and both legs. His general condition was good and he had lost little blood. The circulation in his right foot was poor—the foot was cold and neither the *dorsalis pedis* nor the posterior tibial pulse could be felt on that side, although both were readily palpable on the left side. During excision of the wound on the back of his right calf the peroneal artery was seen. At the level of the mid-calf there was a small hæmatoma around the vessel. Above this the vessel was contracted, but pulsated feebly. Below the hæmatoma there was no pulsation, but the vessel was spastic for only one or two centimetres; beyond this point the calibre was normal despite the absence of pulsation. The anterior tibial and posterior tibial vessels were explored just above the level of the ankle joint, and both were found to be tightly contracted and without pulsation. The hæmatoma was incised and the lesion in the arterial wall inspected. There was found to be a partial tear of the vessel affecting about one-third of its circumference, and the lumen was filled by clot. The clot was removed, the vessel divided at the lesion and ligated above and below it. Almost immediately pulsation returned to the distal segment and to the anterior and posterior tibial vessels, and the foot became warmer.

It is possible that the anæsthetic ("Pentothal") may have produced the relaxation of the spasm, but the time relationship suggested that it was the ligature and division of the vessel which removed the particular stimulus that had been producing the spasm. The evidence of this case has been supported by subsequent ones.

The spasm at the site of injury considerably diminishes the lumen of the vessel, but bleeding often continues, as the ends of the vessel cannot retract. If the external wound is a large one the bleeding is external and the patient may become exsanguinated. If the opening through the skin or the deep fascia is small, a periarterial hæmatoma forms and bleeding stops. Subsequent infection of this hæmatoma may produce secondary hæmorrhage; if it remains aseptic a traumatic false aneurysm may develop; if there is also an injury of the adjacent vein an arterio-venous aneurysm may be produced, a sac forming at the site of the hæmatoma between the two vessels.

If the vessel is a major one, there is commonly an immediate interference with the distal circulation in that limb, which is due to one or more of the following three factors.

1. Intraarterial clot. In some of these cases, if the lateral opening is small and the vessel is a large one, there may be a residual lumen through which the blood can flow past the lesion and into the distal part of the injured vessel; but in practical experience such cases are rare and the value of this contribution to the distal circulation is doubtful. If external hæmorrhage has ceased, the lumen of the vessel is commonly obstructed by clot.

2. Pressure from the extravascular hæmatoma. In those cases in which external hæmorrhage has ceased, there is frequently a tense subfascial hæmatoma, the tension of which not only prevents hæmorrhage, but also causes partial obstruction both of the main vessel and also of the important collateral vessels in that musculo-fascial compartment. This tense hæmatoma constitutes a danger point where infection may start.

3. Arterial spasm. This is seen both in the main vessel and in the collateral vessels.

The Severed Artery.

A completely severed artery often stops bleeding spontaneously, even if it is as large as the axillary or common femoral. In a typical case the left axillary artery was severed in its second part by a gunshot wound, and during excision of the wound the ends were seen to be lying retracted and blocked by clot for 1·5 centimetres, the proximal end flicking in time with the pulse rate. Occasionally the proximal end becomes sealed off in this way while bleeding continues from the distal part of the severed artery. This is known as the Henle-Coenen phenomenon and is a favourable sign, as it indicates that the collateral circulation is not destroyed.

The Ischæmic Limb.

All grades of ischæmia occur, from the mild types, which are often overlooked, to the severe types with rapid and massive gangrene. Some limbs survive, only to require later amputation because of ischæmic contracture which renders them painful and useless.[11][36] An ischæmic limb is particularly susceptible to all types of infection, of which the most important are those by anaerobic organisms.

THE TREATMENT OF ARTERIAL INJURY.

The objects of treatment are: (*a*) to save the patient's life; (*b*) to save his limb; (*c*) to prevent as far as possible the later complications—sepsis, secondary hæmorrhage, traumatic false aneurysm, arteriovenous communication, and ischæmic contracture.

General treatment is very important. Many of these patients are shocked or suffering from blood loss, and apart from the risk to life these conditions militate against the establishment of an adequate collateral circulation[10] and so may determine the loss of a limb. Many patients therefore will require blood transfusion. For preference this should be withheld until a direct attack on the bleeding point is possible; otherwise a transfusion may start a furious bleeding. After operation the hæmoglobin should be raised to as near to normal as possible. The administration of oxygen is of value in assisting the metabolism of the jeopardized tissues.

Let us consider the special treatment of the different clinical types of injury, which present themselves in the following ways.

A. The problems of the large limb vessels.

1. A bleeding vessel is seen.
2. A complete or incomplete lesion of a vessel is seen during excision of the wound.
3. A relatively small external wound is seen near the course of a large vessel, with signs of impairment of the distal circulation in that limb.
4. A small external wound is seen near a large vessel, but the distal circulation is normal.
5. An intact vessel is seen traversing an infected wound.

B. The problems of the smaller vessels at special sites.

1. The "tight calf".
2. The bleeding hand.
3. The bleeding buttock.
4. The bleeding head wound.

The Problems of the Large Limb Vessels.

1. *A Bleeding Vessel is Seen.* Before the patient reaches the surgeon first-aid measures are required. Temporary local pressure is often successful in allowing natural arrest of bleeding. Temporary proximal pressure, with an attempt to apply artery forceps to the ends of a vessel in an open wound, may be necessary and frequently meets with success. The use of a tourniquet

has fallen justly into disrepute, particularly when supervision on the lines of communication is difficult or impossible. These conditions prevailed in New Guinea, where the patient was perforce committed for several hours at a time to the care of half a dozen native carriers, whose attentions, though most devoted and gentle, could hardly be called skilled. There is, however, an occasional place for the tourniquet if other methods of hæmostasis are unsatisfactory, and particularly if the limb is already doomed. Once during a busy night in the mountains a stretcher party of natives brought to the surgical post the body of a soldier who had suffered a traumatic amputation of the right leg; bleeding had apparently recommenced during the journey; had a tourniquet been applied to the stump, he might have survived.

Continuous local pressure by tight bandages is dangerous and may convert a slight wound into a serious one.

A soldier with a small wound through the ankle arrived at a surgical post sixteen hours after he was wounded, with a tight bandage over the wound. His foot was black and crepitant and required immediate amputation.

Once the patient is in the hands of the forward surgical team, there is only one sound treatment for a bleeding vessel, and that is proximal and distal ligation; if the arterial lesion is incomplete the vessel should be divided between the ligatures, as there is evidence that this reduces the risk of secondary hæmorrhage[17] and prevents arterial spasm.[8] Some authorities recommend ligation further away from the lesion—just below the next proximal branch and just above the next distal branch—so as to avoid the cushioning effect of the cul-de-sac which is otherwise formed.[10] Some recommend excision of the damaged segment,[11][15] in the belief that it "may set up spasm in the peripheral arteries". In our cases showing collateral spasm we have found that simple ligation above and below, with division of the vessel at the lesion, has sufficed to allow relaxation of the vessels.

Theoretically, arterial suture or the temporary use of anastomosis by metal tubes, whether lined by vein grafts or not, may be of value; but we have never used these methods. Except at the Borneo landings, we have seldom had a line of communication which could provide the continuous supervision necessary to justify acceptance of the risk of secondary hæmorrhage from a sutured artery. Such wounds are always potentially infected, if not already septic, and the introduction of a foreign body, such as a metal tube, would not be in keeping with fundamental surgical principles.

2. *A Lesion is Seen during Excision of a Wound.* In this group of cases the nature of the lesion may be suspected before operation, but the wound is of such size that it requires excision irrespective of the vascular lesion.

If a completely severed artery is seen, it is ligated above and below the lesion, the ligatures being applied to undamaged vessel. If the clot blocking the ends has extended past the proposed site of ligature, it is "milked out" before the ligature is tied. It is important to ligate the distal end as well as the proximal end, for this procedure may relieve the vasospasm which impedes the collateral circulation. This principle was demonstrated in the following case.

The right brachial artery of a soldier had been severed by a gunshot wound. He was operated on by a surgical team in Borneo, but conditions were difficult and only the proximal end was ligated. Three days later he reached a general hospital, when the right hand was found to be cold and pale and the right radial pulse was not palpable (his general condition was good and his opposite radial pulse was normal). The wound was explored under "Pentothal" anæsthesia and the distal end was found. This was oozing slightly (Henle-Coenen phenomenon), showing that the collateral circulation was not completely destroyed. The distal end was ligated and almost immediately the radial pulse became palpable on that side and the circulation soon after became normal.

The time relation suggested that it was not the anæsthetic but the closure of the leak which allowed relaxation of the collateral vessels.

If a lateral opening is seen, the artery is ligated above and below it and then divided at the lesion. By such a procedure collateral spasm may be released.[9]

"When a large vessel is seen and has obviously suffered contusion and is thrombosed the vessel should be ligated above and below the thrombosed segment and the latter excised." So wrote Makins[14] in 1919, and another war has not altered the soundness of his advice. He points out that it prevents secondary hæmorrhage; and we would add that it may relieve collateral spasm.

3. *A Relatively Small External Wound is Seen near the Course of a Large Vessel, with Sign of Impairment of the Distal Circulation in that Limb.* In this group of cases the wound is of such size or character that while perhaps it would benefit by excision, it does not categorically demand it, and the decision to operate is swayed by consideration of the pathological condition in the underlying vessel.

Many surgeons advise a conservative attitude in these cases.[13][15] We cannot support such advice. Those who advocate conservatism believe that there is frequently a small residual stream of blood through the injured vessel past the lesion, but it is exceptional to find this in practice. The impairment of circulation is due either to a complete lesion or, if the lesion is incomplete, to the presence of intravascular clot, pressure of periarterial subfascial hæmatoma, or collateral spasm. The complete lesion calls for ligature above and below and for evacuation of the surrounding clot so as to decompress the fascial compartment and its valuable muscular collaterals. The incomplete lesion also calls for ligature and decompression (only this can relieve pressure on the collaterals); and this also will help to release collateral spasm and to enable the collateral circulation to expand.[9][17] This procedure will also reduce the incidence of the late complications—traumatic false aneurysm, secondary hæmorrhage and arterio-venous communication, all of which carry with them an appreciable "limb mortality". Those who advocate a conservative policy even go so far as to recommend "making a musculo-fascial barrier over the arterial opening" in those cases in which a partial lesion is seen during excision of the wound.[16] It is hard to find validity in this procedure, which leaves a damaged vessel in an artificial pocket, inviting sepsis and the pressure of a hæmatoma, and preserves an arterial lesion the presence of which can cause collateral spasm.

Despite the contrary weight of authority, one must repeat that the correct treatment for a small external wound near a large vessel in a limb with any impairment of the distal circulation is excision of the wound, decompression of all muscular compartments by wide incision of the deep fascial layers, and exposure of the vessel and, if the vessel is contused or lacerated, proximal and distal ligature and division. Only this procedure can hope to improve the distal circulation. True, many such limbs may survive conservative treatment and happily accompany their owners to vascular centres in the rear areas. Others fall by the wayside, their owners perhaps reaching amputation centres instead. But bare survival of the limb is the lowest standard of success. A circulation which is adequate to prevent gangrene may yet produce ischæmic contracture and thus lead to disability and even later amputation. Therefore, warmth of the limb is not in itself enough to justify complacency—if there is any impairment in pulse or colour of that limb compared with the opposite side, the vessel must be explored. Technical difficulties are no excuse for delaying operation; for the longer the delay, the denser becomes the scar tissue surrounding the lesion, and there-

fore the more difficult the operation and the greater the operative risk to adjacent nerves. Even with the femoral and axillary arteries the main vessel can be temporarily controlled above and below the lesion during the operation. Lighting is not a problem, however uncivilized the country, if one carries an ordinary frontal head light.

4. *A Small External Wound is Seen near a Large Vessel, but the Distal Circulation is Normal.* In this group the decision to operate or not is made purely on the characteristics of the wound itself, and if this is minute and there is no evidence of tension beneath the deep fascia, it can be safely left alone. In some of these cases the late complication of arterio-venous communication occurs, and therefore "any artery that might pass near a wound track should be examined with a stethoscope".[16] This is not the place to discuss the curative treatment of arterio-venous communication, except to mention that the classical delay of operation "to allow the collateral circulation to develop" is sometimes fraught with danger. In one case of arterio-venous aneurysm of the superficial femoral vessels the toes became gangrenous during this waiting period, but the circulation improved as soon as the lesion was treated by quadruple ligation and excision. In some cases, therefore, early operation may save the limb.

5. *An Intact Vessel is Seen Traversing an Infected Wound.* This is sometimes a difficult problem.

A soldier, aged twenty-five years, suffered a gunshot wound of his left arm just above the elbow, with a compound comminuted fracture of the humerus. A few hours later the wound was superficially excised by a surgical team. On the patient's arrival at the general hospital forty-eight hours after he was wounded, exploration of the wound revealed an abscess under the deep fascia, between the biceps tendon and the brachial artery. The artery lay in the wall of the abscess cavity, but was not thrombosed, and pulsated normally. The abscess was drained and the arm immobilized. Two nights later the patient had a fatal secondary hæmorrhage, concealed under a mosquito-net in a blacked-out tent in an understaffed ward.

The artery should have been tied when the abscess was drained. Each such case must be treated on its merits, and since penicillin has been available we have not seen any harm come from draining the wound and leaving the vessel alone.

The Collateral Circulation.

When a main artery has been damaged the fate of the limb depends on the condition of the collaterals. These may be divided, compressed, or in spasm. These collateral vessels are partly the named arteries of the anatomical textbook and partly the unnamed network of tiny muscular arterioles which can dilate if factors causing spasm are removed, and if pressure on them is released. Thus in one dissecting room subject, free from gross evidence of arteriosclerosis, a section through the right arm 10·0 centimetres above the medial epicondyle showed a brachial artery of 4·5 millimetres diameter, and only three small named vessels—the ulnar collateral, of 1·5 millimetres diameter; the posterior branch of the profunda, of 1·5 millimetres; and the anterior branch of the profunda, of 1·0 millimetre. The three smaller vessels had therefore a total cross-section of about a quarter of that of the main vessel; yet ligation of the brachial here seldom produces gangrene and the radial pulse often returns rapidly. At the knee, on the other hand, the named vessels are many, and anatomical textbooks are pleased to depict a grand anastomosis between them; yet gangrene from ligature of the popliteal artery is common. Perhaps the vulnerability of this site is due to the predominance of tendons over muscles at the knee and the consequent lack of the unnamed muscular collaterals which are so numerous in the great muscle bellies of the arm, mid-thigh and calf.

In gunshot wounds there is usually considerable muscle damage, and thus many of the collaterals are severed. Muscle damage is particularly marked with compound fractures, and gangrene is common in a limb with a compound fracture and a severed main vessel. But I cannot agree with the opinion of an experienced surgeon of my acquaintance who once said: "When I see a compound fracture of a long bone with the main vessel severed I always do a primary amputation." This attitude may perhaps be justified in the case of the leg, but surely not in that of the arm, where the functional difference between the natural and the artificial limb is so great that amputation must be avoided if there is the slightest chance of survival of the limb.

Various methods have been tried in attempts to produce relaxation of the collateral vessels—vasodilator drugs, periarterial sympathectomy, injection of the sympathetic ganglia and division of the sympathetic outflow to the limb have been used.[3] We have had no experience of these. The physiological mechanism of vascular spasm has been investigated widely since the days of John Hunter, and a wealth of valuable information has been obtained by animal experiments and at special vascular centres.[2,5,6,7,8,11,12] Many of the conclusions of these workers are in conflict, but it is agreed that in some cases of vascular disease collateral spasm arises in response to a stimulus from the diseased vessel, and Leriche[13] reports improvement in the circulation following excision of a segment of the femoral artery eight inches in length. He points out that "the state of the arterial wall is of greater importance in the establishment of a collateral circulation than the arterial lumen itself". It is surely reasonable to believe that the mechanism of spasm in injured vessels is the same as that in diseased ones, and that the collateral spasm seen in gunshot wounds occurs in response to a stimulus from the damaged vessel wall. We have seen how such spasm does occur and how it may be relieved by simple ligature and division of the vessel even without arterectomy, these observations supporting the view of Elkins.[9] Perhaps in these cases the stimulus arises from the deficiency in the vessel wall, which requires spasm for its closure; when the gap in the vessel wall is closed by a ligature, the spasm is released.

The best way of assisting the collateral circulation, therefore, is to apply early and adequate treatment to the injured vessel and to relieve pressure on the collaterals by the evacuation of any hæmatoma that is present. It is also helpful to warm the remainder of the body (to promote vasodilatation) while cooling the affected limb (to reduce its metabolic needs). Rest is very important in reducing the requirements of the limb; posture is not very important, but most comfort is generally obtained by slight elevation of the limb. The rationale and results of ligating the companion vein or *venæ comites* are still being disputed, but these vessels often demand ligation as a result of coexisting injury. The general treatment outlined earlier may also improve the collateral circulation.

The Problems of the Smaller Vessels at Special Sites.

1. *The "Tight Calf".* A gunshot wound through the posterior fascial compartments of the leg is often associated with subfascial bleeding from the posterior tibial artery or one of its branches, the hæmatoma infiltrating the muscles widely and producing considerable swelling of the leg. Such a calf is an ideal site for the occurrence of anaerobic infection, and there is also sometimes impairment of the circulation in the foot. Surgeons have long realized that the classical medial approach to the posterior tibial artery is made impracticable in such cases by the distortion of anatomical planes and the approach of Fiolle and Delmas has become popular.[1] It is advisable to use a downward extension of their mid-popliteal incision for exposure of the

popliteal artery, rather than their approach to the posterior tibial artery in the mid-calf. The former carries the slight risk of damage to the nerve to the lateral head of the soleus (as pointed out by Henry[9]), but the latter carries the risk of leaving the proximal part of the hæmatoma still under tension. With the former approach one can obtain proximal control of the popliteal artery, good exposure for the discovery of a bleeding point, and complete decompression of the muscular compartments.

2. *The Bleeding Hand.* It has been recommended that uncontrolled bleeding from the hand should be treated by ligation of the brachial artery.[13] This contravenes the surgical principle that hæmorrhage is best controlled by ligation of the bleeding point. A hæmatoma in the hand requires decompression just as does one in the thigh—apart from the possibility of infection, a hæmatoma beneath the palmar fascia can cause serious interference with the circulation in the fingers.

A soldier was struck in the palm of the right hand by a piece of rock from a quarry explosion. He had only a small wound in the skin and there was little external bleeding, but on his arrival at a general hospital an hour later the third and fourth digits were cold and anæsthetic and the concavity of the palm was rather flattened. After evacuation of a hæmatoma from the middle palmar space the circulation and function of the fingers returned to normal.

By the use of properly placed incisions it is better to attack the bleeding point than to trust to a proximal ligature.

3. *The Bleeding Buttock.* A buttock wound may injure the superior or inferior gluteal arteries or their branches close to the great sciatic foramen in the immediate neighbourhood of the sciatic nerve. This is a unique problem, as proximal control of the main vessel is impossible and the blood wells up from the depths of the wound. Blind groping is forbidden by the risk of injury to the nerve. A local exposure must be made, as much to drain the dangerous gluteal muscle mass as in the hope of finding the bleeding point. It may be necessary to put a temporary pack in the opened buttock and then to obtain hæmostasis by ligation of the internal iliac artery. Makins, in writing of secondary hæmorrhage, cites ligation of the internal iliac artery for a bleeding buttock as the only justifiable example of proximal ligation for hæmorrhage at a distance.[10] It may also be required for primary hæmorrhage at this site, as was shown by the following case.

An officer received a wound of the left buttock. Whenever his dressing was removed there was a torrential hæmorrhage. When he arrived at the general hospital a week later this had happened five times. The buttock was explored through a long incision in the line of the *gluteus maximus*. Blood welled up from the vicinity of the sciatic nerve, but it was impossible to see the bleeding point. The buttock wound was therefore packed, and the internal iliac artery was tied through a mid-line abdominal incision. On removal of the packing a few days later the buttock wound was clean and dry.

The main trunk of the vessel must be tied rather than one of its divisions, as one often cannot tell whether the bleeding is from superior gluteal (posterior division) or inferior gluteal (anterior division). In the case described the extraperitoneal route was used, for we had previously seen the internal iliac tied through a transperitoneal approach (for bleeding from the nutrient artery of a shattered iliac bone) with results which were disastrous because of technical difficulties.

4. *The Bleeding Head Wound.* In the treatment of gunshot wounds of the brain, hæmorrhage from the cortical vessels presents a problem, as in forward areas diathermy is not available and one is loath to use dead muscle as a hæmostatic in an infected wound. We later made a practice of carrying Cushing's clips, but prior to this we had occasionally to use a cautery improvised from a pair of artery forceps heated in a primus stove.

CONCLUSIONS.

1. There is clinical evidence that vascular spasm after gunshot injury is similar to that following any other injury, and can impede the distal circulation by affecting the collaterals.

2. Such spasm can sometimes be relieved by local treatment of the vascular injury.

3. If there is an incomplete lesion of an artery it must be explored and dealt with by double ligature and division. This carries more hope for the distal circulation than does conservative treatment.

4. The bleeding buttock wound is the only condition in which proximal ligation at a distance is advisable in the treatment of hæmorrhage.

SUMMARY.

1. The management of certain clinical problems presented by gunshot wounds of the larger arteries has been discussed from the point of view of the field surgeon, who sees all the cases, including those early failures in patients who die or lose their limbs and therefore never reach a special vascular centre. Observations under these conditions are, however, hampered by lack of special facilities and equipment and by difficulty of long-term follow-up.

2. Certain problems of arterial injury at special sites have been discussed.

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RECONSTRUCTION OF OPPOSITION DIGITS FOR MUTILATED HANDS.[1]

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THE explosive weapons and methods of the recent war have left a legacy in mutilated hands. The world over it has been necessary to focus attention on the finesse of plastic repair as applied to the hand.

During a four and a half year period in an army plastic surgery unit,[2] while 630 patients with face injuries were treated, 403 with hand injuries were also treated and in 55% of the latter group of cases gross mutilations had occurred.[3]

In the management of the more destructive hand injuries, mere restoration of the remaining parts to normal has often been insufficient. It must be recognized that good healing and function of the remnant do not always represent the best possible end result (see Figure I). Full consideration must also be given to the possibilities of reconstruction or substitution for parts that are lost. This consideration is always relative to an individual case and is based chiefly on the extent of damage. The greater the damage, the more important is any slight improvement, and the more are we forced to carry out procedures which might well be considered unjustifiable for hands less severely damaged.

Under this duress many ingenious and tedious operations have been carried out on the mutilated hands of this war. Many of these are only of technical interest or have a rare application; but some have after a fair trial become rational procedures, to be known and considered by all concerned with hand injury and repair. One such procedure concerns restoration of the "pinch" function to a mutilated hand by plastic reconstruction of an opposition digit or digits.

The "pinch" or opposition function in a normal hand involves essentially the function of a normal thumb. For this to be effective in a mutilated hand, three considerations must be satisfied: (i) the thenar muscles must be present and active in a functioning state of integrity, attachment and innervation; (ii) there must be an adequate length of projecting thumb; (iii) there must be present an adequate length of finger or fingers to which the remaining length of thumb can become apposed in the movements of opposition and flexion.

Many wounded hands are left without "pinch" function by reason of defects in one or more of these three factors; but provided the first factor is satisfied, their "pinch" function can be still be restored. A free thumb can be remade or adequately lengthened, or a rigid digit can be made to which the thumb element may be apposed. Moreover, in gross cases in which

[1] Accepted for publication on March 6, 1947.

[2] This work was done at the Number 2 Facio-Maxillary and Plastic Surgery Unit, Heidelberg Military Hospital.

[3] By gross mutilations we mean compound injuries resulting in various combinations of finger loss, with or without damage to one or more of the various structures of the remainder of the hand. By compound we mean open wounds involving several tissues, not necessarily just compound fractures.

all fingers are missing, both elements can be constructed to make an animated pair of "pincers".

In an Hunterian lecture, 1939, concerning "The Use and Behaviour of Cancellous Bone Grafts", Mr. Rainsford Mowlem illustrated a case of thumb reconstruction by a soft tissue pedicle and bone graft. Though he does not consider the suggestion unique, we believe this was the first thumb to be reconstructed in this way. The method has since been widely used in this war by most plastic surgeons of the Gillies school. It has been reported and described in relation to individual cases, but such is its present-day application that in our opinion some emphasis should be placed on a description of the basic procedure. This will be elaborated in relation to a personal series of eighteen cases, appropriate details of which are set out in Table I. In earlier cases of this series methods and stages were varied, in order to decide the safest and quickest means of attaining the desired end. Despite a number of setbacks and complications, with consequent time lag, the ultimate object was attained in all cases. The easy pitfalls of the procedure are indicated in the mistakes of this series, and the precautions which it is considered best forestall these pitfalls are suggested in a description of the operation.

FIGURE IA. FIGURE IB.

FIGURES IA and IB. Healed stump with inadequate pinch function.

FIGURE IC. FIGURE ID.

FIGURES IC and ID. End result of thumb reconstruction.

RECONSTRUCTION OF A SINGLE OPPOSITION DIGIT.

If the results of plastic surgery are erratic or equivocal, it becomes uneconomic. For this reason the shortest possible means of obtaining an end result, if associated with a high risk factor, is not always the best procedure for general application. Though an opposition digit can be made in fewer stages, it is considered that a four-stage operation is the most satisfactory means to that end (Figure II).

TABLE I.

Case.			Injury.		Reconstruction of Digits.				Other Repair Procedures Done *re* Hand.	Result.	Remarks.
						Stages.					
Number.	Identification.	Previous Occupation.	Cause.	Residual Deformity.	Extent.	Planned.	Required.	Difficulties, Complications, Delays *et cetera*.			
I	Capt. M.M.W. Age: 31.	Farmer.	Gelignite explosion.	Right hand: First finger amputated. Left hand: First and second fingers amputated. Thumb amputated through first phalanx. Scar contracture third finger.	Left thumb elongation.	4	4	Nil (bone graft was not inserted for three months after soft tissue extension).	Scar excision and whole skin graft at base of third finger done at first operation.	Excellent. Thumb elongation one and a quarter inches.	After five years states: "Thumb has never given trouble. Can do any normal work about the farm except milk cows. With help of one other man, am running 3,500 sheep." Has good sensation at the proximal two-thirds of thumb. End of bone graft gradually became pointed.
II	Sgt. R.B.C. Age: 25.	Carpenter.	Circular saw accident.	Left hand: Thumb amputated. Flexor tendons severed to 1, 2 and 3 fingers with stiff finger joints.	Left thumb reconstruction.	3	5	Pedicle made and attached at first operation, but after slight breakdown, ring scar gave further trouble requiring staged reexcision. Sinus developed at end of stump where circulation was poor; ultimate terminal sequestrum removed.	Secondary flexor tendon repairs in the palm.	Good. Thumb elongated one inch.	After four years states that the thumb is very useful to his work, and full sensation returned. See Figure VIB *re* final appearance of bone graft. He is still a carpenter.
III	Sig. R.M. Age: 34.	Professional musician.	Cut with ax.	Right hand: Thumb amputated through metacarpophalangeal joint.	Right thumb reconstruction.	4	5	Bone graft inserted in pedicle before its detachment from abdomen (Stage 3). This proved difficult and unsatisfactory. There was terminal breakdown after detachment from the abdomen, requiring secondary trimming and closure.	Nil.	Good. Thumb elongated two inches.	Graft was mal-united to metacarpal stump with angulation of the digit; but the ultimate result was highly satisfactory, especially for his work as a professional musician. After four years, the thumb has given no trouble, has a high order of touch sensation, but is "not as good as his normal thumb".

TABLE I.—*Continued*

TABLE I.—*Continued.*

Case.			Injury.		Reconstruction of Digits.				Other Repair Procedures Done *re* Hand.	Result.	Remarks.
					Extent.	Stages.		Difficulties, Complications, Delays *et cetera*.			
Number.	Identification.	Previous Occupation.	Cause.	Residual Deformity.		Planned.	Required.				
IV	Sgt. H.W.B. Age: 22.	Bank clerk.	Shrapnel wound.	Left hand: Thumb amputated. Multiple compound fractures, tendon and nerve injuries of first and second fingers.	Left thumb reconstruction.	4	4	Closed end of soft tissue extension gaped after sutures were removed, requiring secondary suture.	Tendon graft to index finger. An area of flap was arranged over the palm at the initial attachment.	Good function of both thumb and index finger.	Back at his old job in a bank. In three years it has given no trouble and he has some touch sensation.
V	Pte. R.E.P. Age: 25.	Machinist.	Shrapnel wound.	Right hand: Loss of all fingers and thumb.	Reconstruction of two digits.	5	5	Nil.	Removal of bony prominence and scar plastic to dorsum of hand.	Good "pincer" function.	Case illustrated in Figure VII. Most useful and has had no trouble in two and a half years.
VI	Cpl. W.McK. Age: 40.	Railway worker.	Accident with high explosive.	Left hand: Partial amputation of thumb, first and second fingers. Scar of palm.	Left thumb extension.	4	4	Nil.	Nil.	Good apposition. Painful terminal scar retrimmed.	Programme took four months. Bone graft inserted in several pieces which soon united as a mass (Figure XI).
VII	Gnr. R.R. Age: 29.	Farmer.	Landmine explosion.	Left hand: First finger and distal two-thirds of thumb amputated. Tendon injury and scar deformity of second finger.	Left thumb reconstructed.	4	4	Nil.	Tenolysis *re* middle finger and tendon covered with filletted flap from the index finger.	Good thumb apposition function and middle finger restored to normal.	Case illustrated in Figure II. Bone graft illustrated in Figure V. Programme took four months. Early sensory return. Returned to farming.
VIII	F./Lt. C.P.F. Age: 24.	Bank clerk.	Aircraft accident. Hand caught in airscrew.	Right hand: Amputation of thumb and all fingers.	Reconstruction of two digits.	5	6	The rigid apposition digit was made too straight for apposition of the reconstructed thumb. Its metacarpal union was therefore subsequently refractured and the digit fixed with a lean towards the thumb.	Inguinal hernia repaired.	Excellent "pincer" function.	After two years he states: "Hand is very useful and still improving." He uses it for writing, which he does very well. Back at his old job.

TABLE I.—*Continued.*

Case.			Injury.		Reconstruction of Digits.				Other Repair Procedures Done *re* Hand.	Result.	Remarks.
						Stages.					
Number.	Identification.	Previous Occupation.	Cause.	Residual Deformity.	Extent.	Planned.	Required.	Difficulties, Complications, Delays *et cetera*.			
IX	Pte. R.N.C. Age: 20.	Wool clerk.	Gelignite explosion.	Right hand: Thumb amputated near metacarpo-phalangeal joint, first, second and third fingers through first phalanx. Multiple metacarpal fractures. Scar and tendon contracture, little finger.	Right thumb reconstruction.	4	6	Long delay in healing of pedicle end after third stage. Had two secondary closures. This was probably due to too bulky a pedicle and insufficient fat reduction at the initial raising.	Scar plastics to palm and little finger.	Good useful apposition function.	After 18 months remains most effective.
X	Pte. W.K.B. Age: 22.	Transport driver.	Accident with ax.	Right hand: Thumb amputated at metacarpo-phalangeal joint.	Right thumb reconstruction.	4	6	After bone graft an infected hæmatoma caused some breakdown of suture line to make a chronic ulcer and low-grade bone infection. This area was covered by a small direct flap from the abdomen. This closed the defect, but with much loss of time. Distal third of graft ultimately sequestrated.	Nil.	Good useful apposition function, but owing to part loss of bone graft there is not adequate length of bone support for optimum use of the thumb extension.	Had a large amount of penicillin. Though the ultimate result was good, the procedure could not be regarded as economic in this case in view of time period. He has good touch sensation.
XI	W./O. A.S.G. Age: 37.	Commercial traveller.	Gelignite explosion.	Right hand: Loss of all fingers and thumb, including all bone but three middle short stumps of metacarpal bone.	Reconstruction of double digits from carpal tissues.	3	3	Nil. 1. Removal of middle column of carpal and metacarpal bones and soft tissue plastic to make two separate digits. 2. Interchange of insertions of wrist extensors. 3. Wrist flexors elongated by grafts and crossed to insertion at distal ends of digits.	Nil.	Useful range of an adduction gripping function.	Strong adduction but no active abduction of ulnar digit. The thumb digit had active abduction by long thumb abductor muscles.

TABLE I.—*Continued.*

Case.			Injury.		Reconstruction of Digits.				Other Repair Procedures Done *re*. Hand.	Result.	Remarks.
						Stages.					
Number.	Identification.	Previous Occupation.	Cause.	Residual Deformity.	Extent.	Planned.	Required.	Difficulties, Complications, Delays *et cetera*.			
XII	L.A.C. W.R.M. Age: 32.	Clerk.	Gelignite explosion.	Right hand: Amputated thumb through first phalanx. First, third and fourth fingers amputated. Gross scarring of palm and index finger.	Elongation of thumb.	4	4	Nil.	Abdominal flap designed and attached to free scar of web. Free graft about ring finger stump. Further subsequent grafts.	Good useful apposition function.	The operation was a big help to a badly injured hand with so poor residual function. After one year there was a good deal of absorption and tapering of the bone end.
XIII	Pte. L.N.H. Age: 20.	Bricklayer.	Gelignite explosion.	Left hand: Whole hand amputated through carpo-metacarpal joints, except for remnant of thumb metacarpal.	Reconstruction of double digits.	5	6	Alteration of bony alignment at first stage, as in Figure VIII.	Nil.	Good strong apposition function.	See Figure VIII. Had to change his occupation, but the hand has given no trouble in one year.
XIV	Lt. B.M. Age: 23.	Bank clerk.	Bullet wound.	Right hand: Thumb amputated through metacarpal. Tendon injury of index finger. Compound fracture of fourth finger.	Thumb reconstruction.	4	5	Secondary closure of blind end of soft tissue extension, after breakdown of suture line.	Scar excision and flap replacement of palm scar. Open correction of malunited finger fracture.	Good, effective apposition.	After one year has proved very satisfactory and he is very pleased with the result.
XV	Lt. J.R.S. Age: 28.	Mining engineer.	Grenade injury.	Left hand: Thumb amputated through first phalanx. Index finger amputated. Compound wound of middle finger with joint and tendon damage. Flexion deformity of fourth and fifth fingers.	Thumb reconstruction.	4	4	Nil.	Scar excision and flap on middle finger, followed by extensor tendon graft (two further operations).	An excellent range of movement in the thumb. Good apposition.	After six months is still improving.

TABLE I.—*Continued.*

Case.			Injury.		Reconstruction of Digits.				Other Repair Procedures Done *re* Hand.	Result.	Remarks.
					Extent.	Stages.		Difficulties, Complications, Delays *et cetera*.			
Number.	Identification.	Previous Occupation.	Cause.	Residual Deformity.		Planned.	Required.				
XVI	Lt. C.F.M. Age: 31.	Painter.	Gelignite explosion.	Left hand: Thumb amputated through first phalanx. Index through middle phalanx. Middle finger through first interphalangeal joint. Multiple scars of palm. Right hand amputated.	Thumb extension.	4	5	Secondary closure of pedicle required after detachment.	Cineplastic reamputation of right forearm (one extra operation).	Good, useful apposition.	After one year is working as a building supervisor; states his thumb extension is most useful and has given no trouble. There is highly developed touch sensation with some hyperæsthesia.
XVII	F./Lt. R.F.W. Age: 39.	Airman.	Detonator explosion.	Left hand: Thumb amputated through first phalanx. Ring and little fingers amputated through the first phalanx. All stumps with poor terminal scars. (Blinded by same injury.)	Extension of thumb and little finger.	5	6	Bone graft did not unite well. Thumb stump was reopened after three months, bone ends pared and refixed, using tantalum wire.	Nil.	Good improvement in hand function; effective apposition restored. Though the thumb was firm, some mobility persisted at the graft - phalanx junction.	After one year has remained healed and stable. Operation regarded as of special value in view of his blindness. Touch sensation not completely developed; because of his blindness, he is unable to make full use of the digits yet.
XVIII	Sub./Lt. H.W.B. Age: 25.	Law student.	Run over by train (as prisoner-of-war).	Right hand: Amputation of all fingers and thumb completed at operation. Stump remained open for three months.	Reconstruction of two digits.	5	6	Scar between digits altered alignment of the ulnar digit, though both united firmly in two months. Grafts refractured and reset in optimum position.	Scar excision in distal palm and between digits—local plastic flap.	A good, useful "pincer" type hand resulted from an otherwise useless flipper.	In a recent letter, after eight months, he states that the hand is extremely useful and gives no trouble. He is still discovering new things he can do with it.

Stage 1: The Raising of a Tube Pedicle.

Under general or local anæsthesia a standard tube pedicle is made in a convenient position on the abdomen or in the acromio-pectoral region, with due regard for hair disposition. Each site has advantages for individual cases.

FIGURE IIA. Healed stump with inadequate pinch function.

FIGURE IIB. First of four stages in thumb lengthening (see text).

FIGURE IIC.

FIGURE IID.

FIGURES IIC and IID. Second and third stages in thumb lengthening (see text).

FIGURE IIE. Fourth stage in thumb lengthening (see text).

FIGURE IIF. End result.

The skin circumference of the tube is made exactly to the circumference of the stump to be extended. In the case of a thumb extension this is approximately three inches. The tubed portion of the flap need be only the length of digital extension required. As future circulatory insufficiency arises rather from too much than from too little fat in the pedicle, and as a bone graft

has later to be accommodated in its core at a stage when trauma to the fat is undesirable, the pedicle should be made lax by appropriate fat reduction at the time of its initial construction.

Many of the objections raised to plastic repair on the score of time required would be invalid if the possibilities of reconstruction were fully considered in the early programme of management. If we look ahead, much time can be saved and the patient's stay in hospital shortened by overlapping treatment. When the indication is obvious, a pedicle can be made long before the programme would indicate that it should be done. In this way repeated inductions of anæsthesia can often be avoided. It matters not if a

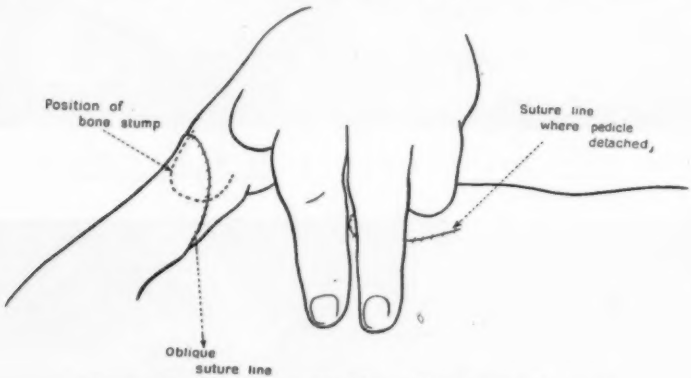

FIGURE III. Method of attaching pedicle to thumb stump.

pedicle is raised long before its detachment, but because of the safe flap dimensions in these cases it can be detached as soon as its linear suture line is soundly healed. The usual interval is three weeks.

Stage 2: Attachment of the Pedicle to the Hand.

Under general anæsthesia the appropriate end of the tube pedicle is detached from the abdomen or chest, and some of the untubed portion of the flap is included. All terminal scar is excised from the stump to be extended. A ring suture line of the pedicle around the terminal end of the stump is to be avoided. Even normal skin is excised if necessary, in order to obtain a larger surface of raw area not only on the end of the stump, but also across one side of the stump, as illustrated in Figure III. The largest possible surface contact between the free end of the pedicle and the recipient area ensures a good attachment. The free end of the pedicle is trimmed to fit exactly this area and its margin of skin edge. Care at this stage obviates most future troubles. For ease of approach at the future bone grafting operation, and in relation to return of skin sensation, the pedicle is best arranged if possible so that its linear suture line faces dorsally. It is sutured to the stump with interrupted fine silk stitches and an occasional end-on mattress stitch is included.

Sutures should not be removed for about ten days. Provided the suture line is well healed and the attachment a good one, the next stage can be done in three weeks. If the attachment is not a good one it will pay handsomely to do a reattachment rather than to persevere through the final stages with a poor or scarred attachment.

The tubing of a flap and its attachment to the stump at a single stage are not advised. The junction of two recent suture lines in two planes at a

vulnerable site is always prone to minor breakdown at this point. The slight resultant scar has a restricting effect at the base of the future digit and jeopardizes future stages. Tubing at a preliminary stage precludes this risk.

Stage 3: Detachment of the Pedicle from the Abdomen.

Usually only a small amount of local anæsthetic solution is required for this stage. The pedicle is severed from the abdomen to leave the length required on the hand for the opposition digit. The abdomen is sutured after the trimming off of redundant tissue. Some fat is removed from the free end of the pedicle now on the hand, to make possible its accurate closure without tension after it has been trimmed to avoid a square-ended "chaff-sack" appearance. This blind end of grafted tissue has a low-grade vitality and the most careful atraumatic technique is called for in its handling and suturing. After being dressed with a light even-pressure bandage, the soft tissue extension is supported by a plaster slab.

The terminal suture line unites slowly, and sutures must not be removed before fourteen days; indeed some of them will often need to be retained for even longer than this. Any failure of first intention healing means long weeks of slow secondary intention healing, or secondary excision and suture may be required.

FIGURE IV. Acrylic splint to support the soft tissue in the interim period before bone graft.

FIGURE V. Method of pegging a single cancellous strut into stump of the phalanx.

This stage, although it involves the simplest operation, is the worst hurdle of the whole procedure.

The next operation can follow only sound healing of the free end. A month's interval is satisfactory; but the longer this period, the better. During this time a more permanent type of slipper splint, made in vulcanite, acrylic or "Celastic", is worn to support the "flabby" soft tissue extension (Figure IV).

Stage 4: The Bone Graft.

Under general anæsthesia the longitudinal suture line of the pedicle extension is reopened about half to one inch short of the distal end, and if necessary the incision is extended on to the normal tissues of the hand. By turning aside the pedicle extension the bone stump is exposed through the wound. This is trimmed of sclerotic bone and its medulla is gouged out with a small spoon to about half an inch.

Cancellous bone from the iliac crest is used as the bone graft. One main strut of bone is used, as in Figure V. One end is fashioned as a peg to be

dowelled into the stump of metacarpal or phalanx; the other end is rounded. It is approximately rectangular in section, with corners rounded. Shaping of the bone graft presents no difficulty provided all its compact face is carefully

FIGURE VIA.

FIGURE VIB.

removed. The graft is arranged in the core of the pedicle and pegged into the open bone stump with as little disturbance as possible. Supplementary free fragments of bone can be used if indicated about the proximal end of the graft or to augment contour or bulk. A few buried catgut sutures unite the fascial and fat

FIGURE VIC.

FIGURE VID.

FIGURES VIA to VID. Some typical end results of thumb reconstruction.

layers over the graft and the skin is sutured with silk. The digit is splinted in correct position by a complete plaster which is left undisturbed for about a month.

After-Care.

After one month the plaster is taken off and sutures are removed. By this time the graft is usually anchored firmly. Daily and slowly increasing active exercises are commenced; but between times a protection splint is worn. The daily application of infra-red light through a layer of wool helps if the local circulation is unduly sluggish in the early period. As function

FIGURE VIIA. The unhealed stump.

FIGURE VIIB. The healed stump.

FIGURE VIIC. Stage in soft tissue migration to form two digits.

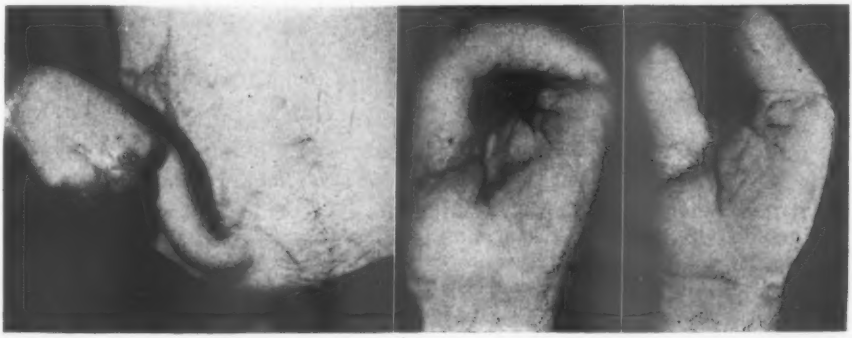

FIGURE VIID.

FIGURE VIIE.

FIGURE VIIF.

FIGURES VIID to VIIF. Stages in soft tissue migration to form two digits.

FIGURE VIIG.
Appearance after bone graft.

FIGURE VIIH.
The end result.

FIGURE VIII.
The end result.

FIGURES VIIA to VIII. Stages in reconstruction of paired opposition digits.

improves and the graft stability is assured, occupational therapy has advantages. Due precautions must be taken in regard to the anæsthetic area. A local, well-fitting glove is worn, appropriately thick in cold weather. These precautions are required throughout the period of sensory return, that is, for about twelve months. Figure VI shows some typical end results.

RECONSTRUCTION OF PAIRED OPPOSITION DIGITS.

Hands devoid of all fingers can still be rendered useful so long as some actively mobile thumb metacarpal bone remains. One mobile digit on the thumb base and one fixed digital extension from the palm can be made on the principle already described. As the same pedicle is used for both digits, it must be proportionately longer, and one extra operation stage is required for the programme as illustrated in Figure VII. The stages of this procedure are: (i) Raising of a long abdominal tube pedicle. (ii) Attachment of one end of the pedicle to the thumb or finger base. (iii) Attachment of the other end of the pedicle to the finger or thumb base to make a soft tissue "U" loop. (iv) Division of the "U" loop to make separate and appropriate lengths of soft tissue extension on the thumb and finger base. (v) Application of bone grafts to both digits. The thumb graft is pegged into the thumb metacarpal; that of the fixed digit is either pegged into a metacarpal stump or wedged between two metacarpals, as best indicated.

SPECIAL CONSIDERATIONS.

Association of Digital Reconstruction with Other Procedures.

Other repair operations in relation to scar, tendon, nerves or bone can be included in the same programme of operations. Indeed, the same soft tissue flap can often be made to serve a dual purpose. Extra soft tissue flap for replacement of palmar scarring in relation to future tendon repair can be carried out either on first attachment or on separation of the pedicle from the abdomen, according to the site for which it is required.

Alteration of Bone Alignments or Relationships.

Alteration of bone alignments or relationships may be required to make the principal requirement of a mobile metacarpal effective before digital reconstruction can be carried out. Figure VIII illustrates an example of this.

More Ambitious Procedures.

When the requirement of active thenar muscles cannot be met, transplants or extensions from other muscle tendons may give some measure of success in activating reconstructed digits. In the badly mutilated hand many free ends of tendons are usually available for consideration which can be elaborated only in relation to the possibilities of individual cases. Figure IX illustrates two digits made entirely from carpal and proximal palmar tissues, by the use of interchanged insertions and extensions from wrist tendons to effect mutual adduction of the digits.

The practical possibility of digital transplants from other fingers to a thumb base has also been demonstrated in various case reports.

THE END RESULT OF RECONSTRUCTED DIGITS.

The Behaviour of the Bone Graft.

Serial skiagrams in this series over periods up to four years illustrate well the behaviour of cancellous bone as a living graft, as described by Mowlem.[1][2] Its high order of vitality, its early union with other bones, its

FIGURES VIIIA to VIIIL. Another example of the staged reconstruction of paired digits. In this case preliminary alteration of alignment was necessary.

high order of resistance to infection, its architectural adaptation and development of a cortical layer have all been illustrated in these cases, despite the embarrassment of the restricted circulation in a grafted soft tissue region. No better example of Wolff's law could be cited than that shown in the

FIGURE IXA. The healed stump.

FIGURE IXB. Final result after bone excision, soft tissue plastic, tendon transplant and grafts.

FIGURE IXC.

serial skiagrams reproduced in Figure X. The early conglomeration of separate bone fragments and subsequent shape adaptation is illustrated in Figure XI.

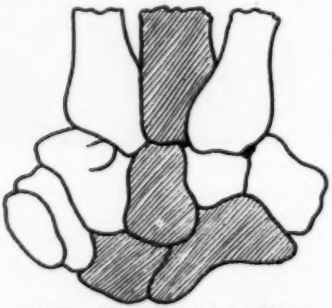

FIGURE IXD. The initial X-ray appearance (tracing).

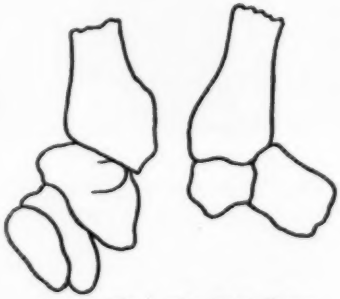

FIGURE IXE. The final X-ray appearance (tracing).

FIGURES IXA to IXE. To illustrate the effective digital reconstruction from a carpus and small remnant of a metacarpus.

Sensory Return.

A slow distal extension of sensory appreciation in the grafted skin area is noted from month to month. Its beginning has been noted even before the bone grafting operation. At first this sensory appreciation is apparent only to a raised threshold of stimulation and is of a crude nature—for example, a pin prick is felt as a tap.

The order of sensory appreciation slowly improves, and as it extends distally the proximal areas are more sensitive than the distal. In cases of over one year's duration sensory return of a high order has been observed in all except scarred areas. We have also noticed that some patients exhibit

FIGURES XA to XF. Serial skiagrams of the same hand at intervals over a period of two years after bone graft.

a peculiar hyperæsthesia and that tactile discrimination is sometimes developed to a higher degree than that existing in the counterpart area from which the skin was taken. The reasons and vital method involved behind these observations are as obscure as most of our present-day knowledge in regard to sensation.

Functional Value of Reconstructed Digits.

The functional value of reconstructed digits is difficult to describe except in relation to specific cases. The best results have been obtained with the more badly mutilated hands or when the restored "pinch" function has had a specific relation to occupation. The attitude, behaviour and will of the subject are the most important factors in a successful outcome of these procedures, and for this reason careful preselection of suitable cases must remain of prime importance if success is to be achieved.

CONCLUSION.

The procedure elaborated indicates an active effort to produce the greatest functional value from the remnant, no matter how small, after severe injury of the hand.

FIGURE XIA. FIGURE XIB.

FIGURE XI. Skiagrams of the same case at an interval of eight months, showing the conglomeration of separate bone fragments and shape adaptation.

The results show that any degree of hand function or movement which can be effected is so much better than an amputation stump and so much better than an artificial hand that a wise surgeon will always err on the side of conservatism in his primary treatment of hand injuries.

ACKNOWLEDGEMENTS.

We are highly appreciative of the work done by the staff of the Number 2 Facio-Maxillary and Plastic Surgery Unit during this series, and are indebted to Sergeant O. Hansen (Women's Auxiliary Australian Air Force) for the photographs, and to Flight-Officer C. Alldritt (Women's Auxiliary Australian Air Force) for the sketches used as illustrations.

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HIRSCHSPRUNG'S DISEASE.[1]

By James A. Jenkins,
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Congenital idiopathic dilatation of the colon was described by Parry in 1825 and from then on until 1886, when Hirschsprung gave the first detailed account of this disease, there were numerous references in medical literature. In 1908 Finney[(1)] published a paper to which little can be added. Subsequent medical literature abounds with reports of cases in which various forms of treatment were used, but there is no sufficiently large series of cases with a "follow-up" record that will permit of an evaluation of the advantages or disadvantages of any particular method of treatment. The largest series is that of Bailey and Haber,[(2)] but more details concerning methods of treatment are required. Wade,[(3)] in an excellent article, describes thirteen cases after sympathectomy in which there was a gradual improvement in most, but in which the final outcome was not known. Most contributions to literature offer smaller series of cases and the final results of treatment are no more definite.

The disease is comparatively rare and there is a distinct need for a registry of cases from a wide area if further knowledge is to be gained. The reports of "improvements" and "partial successes", often supported by X-ray pictures and photographs which convey little real information, and are usually taken soon after operation, do not give an accurate picture of the improvement, if any. It is well recognized that these children vary considerably from time to time, depending on the care and attention bestowed on them.

The complicated problem of the nerve supply of the colon, rectum and anus is touched upon by many authors, but the statements of earlier workers have been in the main accepted without demur. Results have been claimed and at times achieved that appear to me to be based on faulty premises.

Apart from the effect on the disease itself, the effect of various types of sympathectomy on sexual functions requires clarification. The patient H.P. whose history is reported here was refused a sympathectomy by his parents on account of the possible but uncertain ill effects on sexual function in later life. Only by a careful recording of the rami, nerves, or ganglion removed, together with a prolonged "follow-up" of patients into adult years will it be possible to obtain definite information on this point.

An attempt is made in this paper to deal only with certain aspects of Hirschsprung's disease and to present three cases to illustrate points under consideration.

Clinical Histories.

Case I.

M.S., when aged one year, was admitted to the medical wards of the Dunedin Hospital in 1943. The history then given was that he had been constipated since birth—several days intervening between motions. He had been treated continuously with laxatives and paraffin, but without success.

His nutrition was fairly good. The abdomen was greatly and evenly distended. Visible peristalsis was present at times. While in hospital his abdomen became grossly distended and he vomited, but he displayed no evidence of pain. X-ray examinations were not satisfactory. He was treated by colonic lavage with some benefit.

[1] Read at a meeting of the Royal Australasian College of Surgeons at Wellington, September, 1946; accepted for publication on January 22, 1947.

He was readmitted to hospital at the age of three and a half years under my care (October 15, 1945). The bowel difficulty had continued and at intervals there had been gross distension and vomiting. On examination the abdomen was distended and the pelvic loop of colon was found enlarged and easily palpated. The anal sphincter was very tight and spastic. When a finger was inserted into the rectum the tone seemed to vary, but at all times it was much greater than that usually encountered. A barium enema showed gross dilatation of the pelvic colon and rectum, with good tone in the proximal part of the colon (see Figure I). On November 23, 1945, low spinal anæsthesia was induced to see the effect of relaxation of the anal sphincter. The bowel did not empty.

FIGURE I. Case I. Showing gross dilatation of the pelvic and proximal portions of the colon. In this case and those depicted in the following radiographs barium enemata have been given.

On December 18, 1945, I performed a partial bilateral sphincterectomy. The anal sphincter was of considerable thickness and a section one-quarter of an inch wide, extending throughout its whole length, was removed on each side. The wounds were not sutured. After this had been done the anal canal was lax and easily distended.

Convalescence was uneventful. Within three weeks he was having daily bowel motions, but was also still having enemata twice a week to keep the colon empty. He was discharged from hospital five weeks after operation.

Follow-Up. He was seen again six months later, when his mother stated that he had not had any attacks of distension since his operation. She had not given enemata, but had kept him on two drachms of paraffin daily. It was most unusual for his bowels not to act normally once a day. There had been no incontinence. On examination the child seemed a fit, healthy-looking youngster, and the abdomen, though large, would not have aroused any comment if the previous history had not been known. The anal canal felt normal to the examining finger. No dilatation had been carried out since the sphincter had been resected, and the mother was instructed to insert a finger occasionally as a precautionary measure. A barium enema (see Figure II) demonstrated a marked reduction in the size of the rectum and the colon, with evidence of improved tone.

Case II.

H.P., when aged three years and ten months, was admitted to hospital on April 28, 1945, with a history of abdominal distension and of constipation existing since birth. Motions had been obtained only by colonic irrigations. A finger had frequently been inserted into the rectum in an attempt to cause evacuation. Periodically the distension had increased and had been accompanied by vomiting. During these attacks the child, though obviously ill, did not appear to suffer much pain.

On examination he appeared rather frail and anæmic. The abdomen was grossly distended and a huge loop of colon with visible peristalsis was evident. A barium meal on May 7, 1945, showed the proximal part of the colon to about the centre of the transverse colon to be functioning within normal limits, but that megalocolon existed below this.

FIGURE II. Case I Showing marked reduction in size of rectum and colon following sphincterectomy.

On May 1, 1945, high spinal anæsthesia ("Percaine" 1 in 1,500) was induced. Anæsthesia reached the third thoracic segment. Very active peristalsis followed, but there was no evacuation. On May 15, 1945, the high spinal anæsthesia was repeated. Anæsthesia was complete to the eighth thoracic segment and partially to the fifth. Active peristalsis again occurred without movement of the bowels. On May 21, 1945, "Mecholyl" (acetyl-β-methyl choline chloride) administration was commenced by subcutaneous injections—1·0 milligramme, the dose being gradually increased to 5·5 milligrammes—but apart from active painful peristalsis there was no result. Daily enemata were still necessary to relieve distension. On June 19, 1945, I injected the lumbar sympathetic chain on each side. The circulation in the feet increased, but there did not appear to be any change in the abdominal condition. Following the sympathetic block a wash-out produced a copious fæcal result. On July 5, 1945, a barium enema still showed a somewhat dilated caecum and ascending colon and rather more dilatation of the transverse and descending colon. The lower part of the pelvic loop and rectum appeared normal. There was gross dilatation of a big loop of pelvic colon (Figure III). Sympathectomy was considered, but the parents refused this on account of the possibility of subsequent sexual disability.

FIGURE III. Case II. Showing gross dilatation of the loop of the pelvic colon.

On July 10, 1945, the abdomen was opened by an oblique incision on the left side. A huge loop of distended and hypertrophied pelvic colon presented itself. Below this loop the dilatation terminated abruptly about four inches above the rectum, where the bowel, although hypertrophied, had a lumen of normal size. Above the loop the colon appeared grossly dilated and thickened, but to a much less degree than in the pelvic colon. The colon was removed from the centre of the transverse colon to below the dilated part, and both cut ends were brought out through the incision as in a Mikulicz-Paul operation. Progress was uneventful and the colostomy worked daily in a normal way. On August 9, 1945, a crushing clamp was applied to the spur. The spur was short and was not very satisfactory for this procedure, and subsequently the fistula was closed on September 21, 1945. The anal sphincter was dilated digitally.

FIGURE IV. Case II. Following partial colectomy, showing relatively normal ascending colon with considerable dilatation of the transverse colon and a rather spastic pelvic colon and rectum. (In the preparation of this illustration the sides have been reversed.)

Progress. The general condition improved greatly —there was no evidence of any abdominal distension and the bowels worked normally while the patient was in hospital. In August, 1946, the parents reported the condition as unsatisfactory. An opaque enema on August 9, 1946, shows (Figure IV) a normal ascending colon with considerable dilatation of the transverse colon and a rather spastic pelvic colon and rectum. The appendix was dilated. The anal sphincter was again very spastic. When a finger was passed into the anal canal it was very tightly gripped.

Further Operative Treatment and Later Progress. A bilateral partial sphincterectomy was therefore performed. Since then there have been daily motions without the use of paraffin or other laxative. An X-ray examination on August 26, 1946 (Figure VA) revealed some improvement in tone of the colon. Clinically the abdomen was normal. Two months later the child was reported to be having daily motions and was symptom free. An X-ray examination on November 22, 1946 (Figure VC), showed well-marked haustration and good tone.

Case III.

R.P., aged six days, was admitted to hospital on April 29, 1943, with abdominal distension and vomiting. Very little fæces had passed since birth. A subacute obstruction was considered probable. Flat X-ray examination showed the colon to be full of gas. A barium meal passed through the intestinal tract normally. The child was readmitted to hospital at the age of three weeks with vomiting and constipation. After digital dilatation of the anal sphincter the bowels worked normally while the child was in hospital. The anus was thought to be unusually spastic.

Readmission to hospital on March 10, 1944 (at ten months of age) on account of burns disclosed a history of intermittent attacks of abdominal distension. A barium enema given on March 22, 1944, showed gross dilatation of the whole colon, the distal

colon being most markedly affected. The pelvic colon was elongated and dilated, but the rectum was normal. On April 4, 1944, high spinal anæsthesia (1 in 1,500 "Percaine") was induced. This was repeated on April 11, 1944, April 18, 1944, and May 1, 1944. On the last occasion only was there any result, much flatus being passed.

The next admission was on May 15, 1946 (at the age of three years). Since the previous discharge the child had suffered continual trouble with distension and constipation. At no time had there been evidence of any pain. The mother had dilated the sphincter digitally at intervals with some relief. On examination there was considerable abdominal distension which varied from day to day. Visible peristalsis occurred in the transverse colon and a large loop of pelvic colon. The anal sphincter was not abnormally spastic. On May 20, 1946, an opaque enema was given. The whole colon was dilated (see Figure VI). The transverse, descending and pelvic sections of the colon were most affected. The lower two-thirds of the rectum was normal. The heart was found to be lying transversely owing to subdiaphragmatic pressure (Figure VII). Ten days subsequent to the enema X-ray examination revealed a large part still retained in the distal portion of the colon (see Figure VIII, lateral view). (Note on this lateral view the apparently normal rectum verging into the dilated pelvic colon.)

FIGURE VA. Case II. Showing lessened distension following sphincterectomy.

On May 31, 1946, removal of two segments of the *sphincter ani internus* was carried out and at the same time the colon was thoroughly irrigated.

On June 3, 1946, acute distension occurred and high spinal anæsthesia was induced with some relief. On June 25, 1946, high spinal anæsthesia induction ("Percaine" 1 in 1,500) was repeated, but although there was very active peristalsis, no fæces or flatus passed.

On July 4, 1946, the condition was unchanged—coils of the pelvic colon and transverse colon were visible with active painless peristalsis. Operation for removal of the large pelvic loop together with as much of the adjacent bowel as was thought advisable was suggested, but was refused by the parents.

On July 16, 1946, distension was markedly less; the child had been having daily irrigations. The parents then decided to take the child home, where they agreed to further surgery at a later date. On September 10, 1946, the patient was much improved in general health and the abdomen was only slightly protuberant, though coils of intestine could be palpated. The parents stated that since discharge from hospital the bowels had opened daily without laxatives or irrigations. On October 5, 1946, the mother reported further attacks of abdominal distension, though flatus was passed much more readily than prior to the sphincterectomy.

On the child's fourth admission to hospital on November 16, 1946, the mother stated that the abdominal distension had been much less and that bowel action had been

obtained fairly readily with paraffin given by mouth and with the use of occasional enemata. There had, however, been infrequent attacks of distension and discomfort.

On November 19, 1946, operation was performed. General anæsthesia was combined with a field block (procaine) and the abdomen was opened by a left oblique muscle-splitting incision. The pelvic colon formed an elongated loop and it appeared to merge gradually into the rectum below. The distension involved the entire colon proximal to the pelvic loop, but it was involved to a less degree. The left lumbar sympathetic chain was removed from the fourth ganglion up to above what appeared to be fused second and third ganglia. The pelvic colon, descending colon and distal part of the transverse colon were readily exteriorized and removed by the Mikulicz-Paul procedure.

FIGURE Vb. Case II. Taken on November 22, 1946, showing contracted bowel, good tone, well-marked haustration.

The child stood the operation well and left the table in good condition. Six hours later respiration suddenly became very rapid. The pulse became almost uncountable and symptoms of shock appeared. An examination showed a massive collapse of the right lung. Death took place fifteen hours after operation.

Comment. That interabdominal pressure had reduced the capacity of the thorax is seen by reference to Figure VIII. The danger of this was not appreciated. It raises the question of the advisability of delaying any resection of the colon until the chest has been given an opportunity to develop more fully. The marked improvement following sphincterectomy suggests that in time the pressure effects on the thorax will diminish and an operation may be more safely performed if carried out after a lapse of two or three years.

OPERATIVE TECHNIQUE FOR PARTIAL BILATERAL SPHINCTERECTOMY.

Before attempting the operation of partial sphincterectomy the surgeon should make himself conversant with the surgical anatomy of the anal canal, as described by E. T. Milligan and C. Naughton Morgan in *The Lancet,* Volume II, 1934, page 1150.

With the patient in the lithotomy position the lower border of the internal sphincter is palpated. A three-quarter inch incision is made on each side of the anal canal at this level (Figure IX, 1). With scissors the inner border of the subcutaneous external sphincter is defined and also the lower border of the internal anal sphincter (Figure IX, 2). The anal mucosa is freed up to the ano-rectal ring (Figure IX, 3) and the outer surface of the internal sphincter defined to the same level (Figure IX, 4 and 5). Care is

taken not to penetrate the mucous membrane. A wedge of sphincter is removed; the whole depth of the muscle is taken and the wedge is about a quarter of an inch in antero-posterior length at the lower border of the muscle. This procedure is repeated on the opposite side (Figure IX, 6). Sulphanilamide powder is applied. No sutures are inserted and a tube and "Vaseline" gauze dressing are placed in the anal canal. The striking anatomical feature is the clear-cut definition of the internal anal sphincter and the ease with which it can be freed from the external sphincters on the outer side and the mucosa on the inner side, once the correct plane of cleavage is entered.

FIGURE VI. Case III. Showing gross dilatation of the whole colon with the exception of the lower two-thirds of the rectum.

SURGICAL ANATOMY AND PHYSIOLOGY AND MEGALOCOLON.

The published notes of Langley,[4] Langley and Anderson,[5] and Gaskell[6] provided in part the physiological basis for some of the work of Royle and Hunter. Hunter[7] in 1924 noted the tonic contractible effect of the sympathetic upon the internal anal sphincter and its inhibitory effect on the bowel. The reciprocal innervation with the pelvic nerves (*nervi erigentes*) already worked out by Langley and Anderson was confirmed. Hunter states:

> The continuously acting inhibitory effect upon the muscle of the wall and the tonic contractible effect upon the internal sphincter lead to filling of the bowel. The pelvic nerves which relax the sphincter and contract the gut wall have the effect of emptying the gut.

The work of Learmonth and Markowitz[8] in 1929 and of Rankin and Learmonth[9] in 1930 confirmed the findings of Langley and Anderson[5] that the internal anal sphincter was caused to contract by stimulation of the lumbar sympathetic outflow, and since then nearly all contributors to the literature have adopted this belief. The principle of a dual innervation—the sympathetic system being motor to the sphincter and inhibitory to the rectum and colon and the parasympathetic system (*nervi erigentes* or pelvic nerves 2, 3, 4 and the sacral nerve) acting conversely—has been almost universally

accepted by surgeons, and on this assumption various types of sympathectomy have been performed. It is to be noted that Learmonth and Markowitz[9] worked on dogs, and it is possible, though unlikely, that in the human being the nervous control is fundamentally different.

R. C. Garry[10] writes:

> One is apt to wonder how permanent is the effect of interruption of the lumbar outflow. In experiments where recovery of the animals occurs the effect seems to be transient . . . the exclusion of the thoracic lumbar impulses in cats leads to nothing abnormal in the activity of the digestive tract.

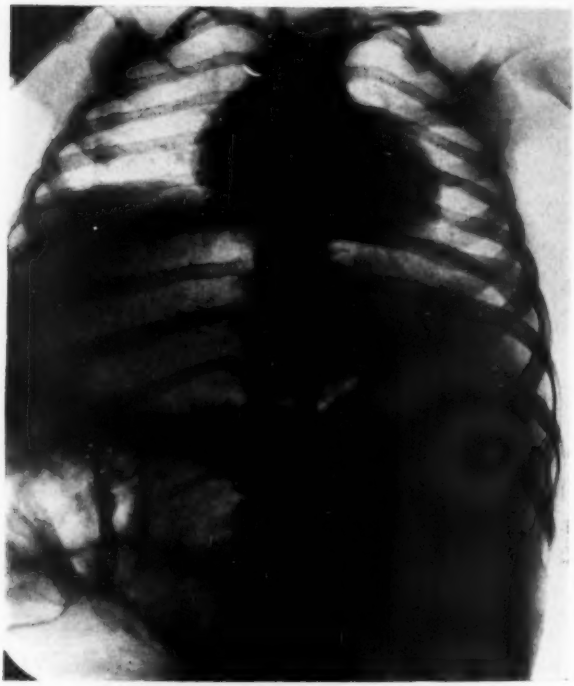

FIGURE VII. Case III. Showing displacement of the heart due to pressure on the diaphragm.

The literature contains a mass of contradictory evidence in which different results appear to be obtained by observers using various types of animals. The most suggestive piece of evidence brought forward by Rankin and Learmonth[9] in favour of the sympathetic control over the internal anal sphincter appears to be an experiment conducted during an operation on a patient in whom the presacral nerve had first been divided and then stimulated at its distal end. The observer found that the anal sphincter contracted tightly on the finger. The application of a hæmostat to the presacral nerve also caused the anal sphincter to contract.

The experimental conclusions arrived at by Learmonth and Markowitz[9] working on dogs may be summarized as follows:

1. The sphincter derives a certain amount of motor innervation through the lumbar sympathetic outflow.
2. The majority of the fibres concerned are post-ganglionic fibres arising in the inferior mesenteric ganglion.
3. Stimulation of the hypogastric nerves caused contraction of the sphincter.

Hunter[7] had previously arrived at the same conclusions. Most sympathectomies for Hirschsprung's disease have been based on them. Another assumption, and one which is backed in many cases by strong clinical evidence, is that the tone of the colon is increased after sympathectomy.

There is, however, very strong evidence against the view that the sympathetic has any effect on the *sphincter ani internus*. Some simple everyday observations bear on this:

1. Under low spinal anæsthesia, one that involves the sacral nerves only, both the internal and external anal sphincters lose all tone. Anæsthesia to this level can have no effect on the sympathetic outflow, and, if the sympathetic had the function ascribed to it, the internal anal sphincter would still maintain its tone.

2. If a presacral neurectomy with division of the lumbar colonic nerve is performed (and this procedure has been done on many occasions), the internal sphincter should be without nerve supply. If this was the case these patients would be in the unhappy position of having to use their voluntary sphincters at all times in order to maintain control. Denny-Brown and Robertson,[111] when working on the physiology of defæcation, showed very clearly that the internal anal sphincter is on constant guard and relaxes only to a conditioned reflex which normally depends on the contraction of a loaded pelvic colon combined with the approval of higher cerebral centres. The external sphincter mechanism, being concerned with striped muscle, is called upon to avert accidents during the stress of daily life. It is not likely that presacral neurectomy would continue to be performed if its action on the internal sphincter was that usually ascribed to it.

FIGURE VIII. Case III. Showing the apparently normal rectum merging into the dilated pelvic colon.

3. Jenkins,[99] from observations on effects of surgical removal of the rectum, came to the conclusion that the internal anal sphincter is entirely independent of the lumbar sympathetic nervous control.

4. Injuries to the sacral cord and *cauda equina* cause anal incontinence in spite of an intact lumbar sympathetic outflow.

5. During the course of abdominal operations I have on four occasions stimulated the presacral plexus, the hypogastric nerves, and the region of the inferior mesenteric artery with a faradic current using bipolar electrodes. The results have an interesting bearing on the work of Learmonth and Rankin, and of Langley and Anderson. In all cases the tone and contraction of the sphincter were judged by an observer's finger in the anal canal.

In one case a presacral neurectomy was being performed and after the presacral nerve had been defined the plexus was lifted up and divided, and the distal end was stimulated. There was no apparent change in the tone of the anal sphincter. In the other three cases stimulation was carried out in the course of lower abdominal operations, and various parts of the presacral

and hypogastric nerves were contacted with bipolar electrodes. As the electrodes moved down to the front of the sacrum there was twitching of muscles of the leg and gluteal region and also some contraction of the anal sphincter. The strength of the current used in all cases was just sufficient to cause contraction of the rectus muscle exposed in the abdominal wound when it was touched directly by the electrodes. With a finger in the rectum it

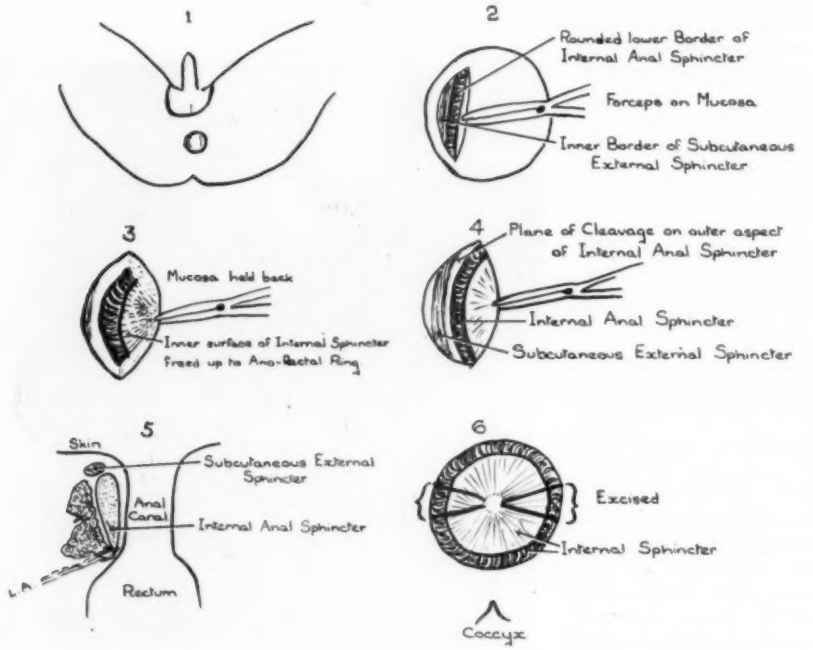

DIAGRAM ILLUSTRATING TECHNIQUE OF BILATERAL PARTIAL SPHINCTERECTOMY

FIGURE IX.

was difficult to say whether the internal sphincter or the external sphincters were contracting. It would appear, however, from the absence of contraction on stimulation of the distal end of the hypogastric nerve, and the presence of contraction when the electrodes lie over the region of the anterior sacral foramina, that the effect as far as the sphincter is concerned is on the anterior primary divisions of the sacral nerves. The slight contraction felt in the sphincter is probably due to stimulation of the pelvic nerves (*nervi erigentes*), but spread of current affecting the nerves from the sacral plexus to the voluntary sphincter cannot be excluded. When instead of a bipolar electrode a neutral pad is placed on the sacral region and a small electrode is used to stimulate the nerves in the pelvis, spread of current causes contraction of both lower limbs and the anal sphincter. In the experiment described by Rankin and Learmonth the possibility of spread of electric current (down the sectioned hypogastric nerve) to stimulate the "pelvic nerves" has not been taken into consideration.

Wade and Royle[10] described two cases of megalocolon; in one dilatation of the ileum followed a colectomy with ileo-colic anastomosis, and in the other a left sympathetic division and ramisection gave a satisfactory result.

They endorsed the previous work of Royle and Hunter[7] on the "plastic tone of the [anal] sphincter" and pointed out that in megalocolon there might be no spasm but still achalasia. They pointed out that excessive sympathetic action might fix postural tone.

The effect of the sympathetic on postural tone of the anal sphincter in the sense discussed above would appear at the present time to be uncertain. There appears to be little supporting evidence. That the anal sphincter is very spastic in some cases of Hirschsprung's disease is appreciated by many observers (Fenwick[15] in 1900, Bartle,[16] Hurst,[17] Ladd and Gross,[18] Gabriel,[19] and Hurst[20]). Fenwick[15] incised the sphincter on one side; but after healing by granulation the sphincter became as tight as before the operation. Hurst[20] reported cures in a high percentage of cases by carrying out persistent anal dilatation with a vulcanite dilator, but it is to be noted that most of his patients were in a much older age group than those usually classified as suffering from Hirschsprung's disease and the diagnosis might not in all cases be accepted. The very good result obtained in Case I reported in this paper indicates that at least in some cases the anal sphincter is a factor of sufficient importance in this disease for all symptoms to cease after it alone has been effectively reduced in function.

That a simple operation, carrying very minimal risks, may in itself produce a cure and, failing this, may make relief more certain when combined with further surgical procedures, would suggest that the procedure described should be considered in cases of Hirschsprung's disease and should be performed in all cases in which there is any suggestion of spasm or hypertrophy. Cases in which dilatation of the rectum exists down to the anal sphincter would be expected to give the best results. However, in cases in which the rectum is not apparently dilated benefit may also be obtained. The explanation is that in these cases the rectum is narrowed because it is hypertrophied, and if the obstruction of the sphincter is relieved the hypertrophied segment can then function normally. Hurst[17] mentions the thickening of the rectal wall and suggests that it gives way to dilatation less readily than does the colon above.

Much has been written about a pelvi-rectal sphincter (sphincter of O'Beirne) as a cause of obstruction. There would not appear to be any evidence in support of this. The ease with which fluids flow up the bowel makes it highly improbable that any sphincter exists. There is, however, very strong evidence that a mechanical kink (Perthes, 1905) may develop as a result of elongation of the pelvic loop of colon following its persistent distension. One is forced to the conclusion that once the pelvic colon has become a distended elongated coil with secondary fibrotic changes it is unlikely that a good result can be achieved unless its removal forms one of the therapeutic measures employed.

Segment resection of the pelvic colon has been practised by several surgeons. I think it very probable that many resection operations have in the past been much more extensive than the disease warranted and that proximal colon has been removed in cases in which improvement would have occurred once the distal obstruction was dealt with. Whitehouse, Bargen and Dixon[21] favour segmental resection, and Yeazell and Bell[22] suggest the procedure in cases in which no response follows high spinal anæsthesia.

If there is any evidence of mechanical obstruction by kinking at or above the pelvi-rectal junction, the loop of colon should be removed by a Mikulicz-Paul procedure through a left oblique incision. A left sympathectomy would add little to the procedure. In Case II the excision extended to the centre of the transverse colon. The technical difficulties were not great, as the colon

was empty at operation and the stretching caused by its previous distension made its attachments easily accessible.

NERVOUS CONTROL OF THE COLON IN HIRSCHSPRUNG'S DISEASE.

Royle and Hunter's[7] paper expresses well a possible mode of action of the sympathetic in Hirschsprung's disease:

> Excessive action of the sympathetic fibres fixes any posture which is imposed or fixes the increased amount of distension caused by the accumulation of bowel contents. The sympathetic nerves are inhibitors of the action of the bowel, but possibly the original physiological sense is not quite accurate. It might be that the action is to fix the posture imposed mechanically by the bowel contents.

Most authors who favour sympathectomy as a method of treatment have postulated an inhibitory action on the colon by the thoraco-lumbar sympathetic outflow. The good effects of lumbar sympathectomy claimed by a few observers, the considerable improvement reported by many and the complete failure described by others make it very difficult to evaluate either the effects or the worth of this operation.

White and Smithwick[33] state that after denervation of the normal rectum and colon no alteration was visible on the basic tone of the bowel, its peristaltic activity or its sensory activity. They also point out that in megalocolon clinical evidence is incontravertible that the dilated and hypertrophied colon evacuates itself more readily after removal of its sympathetic nerve supply.

Dragstedt[32] in a series of cases in which the nerves were resected above the diaphragm for the reduction of gastric acidity found no evidence indicating a decrease in motility of the intestines. If there was any effect at all, peristalsis was increased and patients suffering from constipation were relieved by this operation.

If Dragstedt's findings are confirmed, it would appear that section of either the sympathetic or the parasympathetic fibres tends to cause increased motility of the intestines. The divergent operative procedures carried out on the sympathetic for the relief of megalocolon do not at present tend to make the position any clearer.

1. Wade and Royle,[14] for instance, did a ramisection of the white ramus to the first lumbar ganglion (and the importance of this is stressed) with division of the medially directed fibres from the first, second, third and fourth lumbar ganglia. The sympathetic trunk was divided below the fourth ganglion. The operation was done on the left sympathetic chain only.

2. C. H. Best and N. B. Taylor[34] state that the fibres to the descending iliac, pelvic colon and the rectum arise from the second and third lumbar segments.

3. E. Star Judd and A. W. Adson[22] favour removal of the second, third and fourth lumbar ganglia with the intervening chain and rami, and in extensive involvement of the colon this is done on both sides.

4. Wade[26] later removed the first and second lumbar white rami and the four post-ganglionic fibres and severed the sympathetic chain below the fourth lumbar ganglion.

5. E. D. Telford[27] in 1934 removed, as suggested by Wade, rami in the neighbourhood of the first and second lumbar ganglia to the aortic plexus, and later in 1939 this procedure was carried out on both sides. Telford[25] then urged a bilateral transperitoneal procedure, dividing the lumbar splanchnics, and removal of the ganglionic chain to prevent recurrence. He is supported in the need for bilateral operation by Oldham,[29] who resected extraperitoneally the second and third ganglia and their rami.

6. Rankin and Learmonth[9] favoured removal of the presacral nerve and the lumbar colonic nerves (inferior mesenteric plexus).

All these operations achieve in varying degree as regards completeness and permanence, and also as regards ease or difficulty of performance, an interruption of sympathetic nerve fibres. The fact that such a wide range of procedures is reported to have produced benefit makes the assessment of any particular operation difficult and indicates the need for more careful observations of the end results with each type of operation. In particular definite information is wanted on the following points.

1. The value of unilateral as compared with bilateral procedures. *Comment*: As the colon develops as a mid-line structure hanging on a mesentery supplied by mid-line vessels it is very improbable that it acquires later in life a purely unilateral nerve supply.

2. The value of removal of the sympathetic chain as compared with various forms of ramisection. *Comment*: The permanence of the result, the possible sensitization to adrenaline induced by the removal of ganglia, and the effect of pre-ganglionic as opposed to post-ganglionic section require analysis and comparison.

3. The value of division of the white ramus to the first lumbar ganglion as stressed by Royle and Wade. *Comment*: In most recent publications the sympathectomy extends up to include the second lumbar ganglion and the first is not touched.

4. The value of a more radical sympathectomy and splanchnectomy (fifth dorsal) as is done in hypertensive cases (Smithwick operation). *Comment*: If high spinal anæsthesia (up to the fifth dorsal segment) is required to obtain results in Hirschsprung's disease it is curious that a sympathetic removal extending only up to the second lumbar ganglion may cause improvement.

5. The side effects of an unpleasant nature that may indirectly result. This applies particularly to the possible effect on ejaculation in the male. *Comment*: Very conflicting statements are made by various writers on this point.

6. The effects of interruption of the sensory nerve supply to the colon. *Comment*: Sensation appears to be diminished in the involved gut in Hirschsprung's disease and the sympathectomy presumably reduces this still further. Possible dangers of cutting out sensory pathways are mentioned by Grimson-Vandegrift and Dratz.[30] White and Smithwick[13] produce proof that the splanchnics carried pain fibres from the colon.

7. The effects of division of the fibres arising from the pelvic nerves. *Comment*: They have been shown to ascend along the course of the hypogastric nerves to supply the colon (Trumble[31] and Telford and Stopford[32]).

It is not proposed to refer here to the numerous reports of patients treated by sympathectomy by various authors. It would, however, appear that this operation should be performed during the early years of the child's life, before gross and irreversible changes have occurred in the colon. It is unlikely that any sympathectomy can be of help if the response to high spinal anæsthesia or a lumbar sympathetic block is not satisfactory, and in the presence of mechanical kinking in the pelvic colon no sympathetic release is likely to be very successful.

Many conditions reported as cases of Hirschsprung's disease appear to be in reality true mechanical obstructions, though it is probable that the first may result in the second in certain circumstances. It is noticeable that fluid

may be injected into the colon and become trapped. This can occur both in a simple mechanical obstruction and in the apparently similar condition resulting from Hirschsprung's disease. In a genuine Hirschsprung's disease the disability commences at birth.

In Case III a notable feature with the child under high spinal anæsthesia was the very powerful peristalsis present and yet the failure of passage of flatus and fæces. A finger could be inserted past the rectum into the pelvic colon, a soft fæcal mass could be felt and a rectal tube passed high into the pelvic loop, but the type of bowel contraction was such that there was no tendency to the onward passage of fæces and flatus. I have noticed this painless and purposeless "peristalsis" on other occasions.

This raises the question of the intrinsic nerve supply of the colon in Hirschsprung's disease. Tiffin, Chandler and Faber[33] reported a case in which at autopsy there was an absence of Auerbach's plexus at the point of narrowing in the sigmoid colon. The plexus above this point was normal. Hurst[17] described degenerative changes in the plexus in thirty cases investigated. Cameron[34] reported similar findings. Most observers who have reported changes in the plexus in the distended bowel, considered these changes to be secondary to the chronic inflammatory and fibrotic changes in the colon. Until more is known of the part the plexus normally plays, of the extent to which it is developed in the normal colon at different levels, and of the relationship, if any, that its absence bears to the disease, it is not possible to offer more than speculation. From examinations made for Auerbach's plexus in the normal pelvic colon in the department of pathology it would appear that reports of abnormality or absence of the plexus require much more investigation than has been made up to the present time. Difficulties of demonstration of the plexus are very considerable.

Another feature of these cases awaiting explanation is the variability in the extent and degree of distension of the large bowel proximal to the site of obvious disease. It is difficult to say, in spite of dilatation of the proximal part of the colon, how much is actually involved by the disease itself. Any colon proximal to a chronic obstruction will show hypertrophy and dilatation, and many of these cases show radiologically well-marked haustration at times. The reports of results following a segmental resection of the pelvic colon support the theory that in some cases at all events the proximal distension is a result of the distal obstruction.

A further problem that requires solution is the effect of high spinal anæsthesia. High spinal anæsthesia (up to the fourth dorsal segment) was found by Telford[36] and Telford and Simmons[35] to give satisfactory results in several cases. Cure was not complete and no explanation was given as to how permanent improvement resulted from this procedure. Other observers (Hawksley[36]) reported twelve cases with six cures and three improvements, and it was noted that improvement was often delayed, and Court[37] also refers to the delayed response. The response in all hands appears to be better in very young children. Miller[38] gives a good review of technique.

This procedure, though repeated several times, appeared to be without effect on the cases reported here. It would, however, appear to be one worth trying, firstly for any possible good it may directly achieve, and secondly as a diagnostic measure indicating the effect of sympathetic release on the colon.

It is of interest to note that for high spinal anæsthesia to be effective the thoracic splanchnics (fourth dorsal) have to be affected, whereas apart from attacks on the sympathetic nerve supply of the small intestine, surgeons have been content to limit their activities to the lumbar outflow. If a high interruption is necessary in the one case (high spinal) it is difficult to see

how success is achieved by the surgical interruption at a lower level (lumbar sympathectomy).

The work of Denny-Brown and Robertson[11] on the defæcation reflex has an important bearing on Hirschsprung's disease. A failure of development of the defæcation reflex would account for some of the features of the disease. A disordered reflex associated with hypertrophy and spasm of the internal anal sphincter, combined with a diminution of sensory activity of the colon,

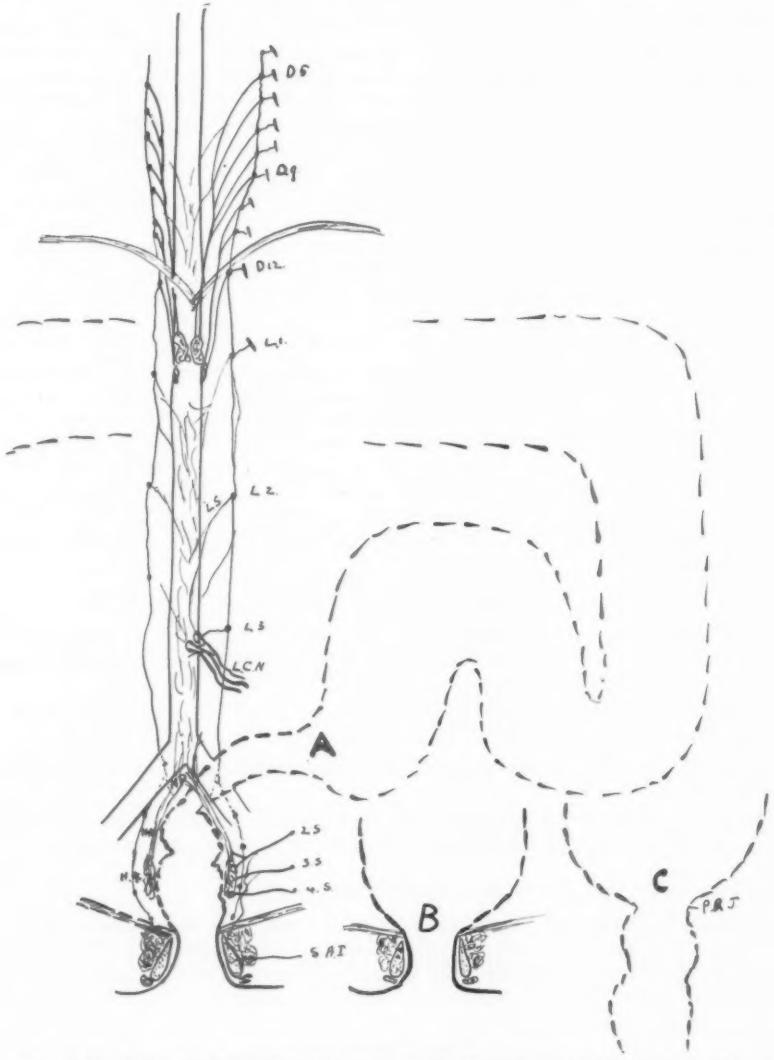

FIGURE X. Diagram illustrating three types of Hirschsprung's disease and main nerve pathways. A = type with dilatation commencing in the pelvic colon; B = type with dilatation commencing at anal canal; C = type with dilatation commencing at pelvi-rectal junction; S.A.I. = *sphincter ani internus*; 2.s, 3.s, 4.s = pelvic nerves or *nervi erigentes*; H.G. = hypogastric ganglion; H.N. = hypogastric nerve; H.P. = hypogastric plexus; L.C.N. = lumbar colonic nerve; D.5 to L.3 = ganglia of sympathetic chain; L.S. = lumbar splanchnics.

would account for most of the features. It is possible that the degree to which in these cases a response to treatment is obtained depends in the main on the extent to which the defæcation reflex has developed. If this assumption is the correct one, then in future all forms of treatment will necessarily be directed to the segment of bowel from the pelvic colon down.

METHOD OF APPROACH IN DEALING WITH CASES OF HIRSCHSPRUNG'S DISEASE.

Following full radiological investigation the induction of high spinal anæsthesia is the logical first line of attack. It may in itself produce results and may also yield information as to the possible results of a sympathectomy. Either at this time or following a second induction of spinal anæsthesia the operation of bilateral partial sphincterectomy should be performed. Little risk is attached to either of the above two procedures, and following them any further surgical treatment should be delayed in order to assess the effects of treatment, to permit the patient to build up resistance and to improve thoracic development.

All patients with gross dilatation of the pelvic loop of colon should then have this loop removed by a Mikulicz-Paul type of operation. At this time the left lumbar sympathetic chain can be readily removed from the second to the fourth lumbar ganglion. If the patient has been carefully prepared, the collapsed bowel leaves peritoneal attachments so free that resection to the centre of the transverse colon can be carried out through a left lower oblique abdominal incision, as in Cases II and III. In these three cases complete relief was obtained by internal sphincterectomy in one instance, by partial colectomy followed by sphincterectomy in another, and in the third sphincterectomy produced a marked improvement, the patient to be lost by a complication following partial colectomy and sympathectomy.

If I should encounter in the future any case which does not yield to these procedures I would consider carrying out in addition a right lumbar sympathectomy.

SUMMARY AND CONCLUSIONS.

1. Three cases of Hirschsprung's disease are reported in which a new form of surgical treatment is adopted. This consists of excision of portions of the internal anal sphincter.

2. The surgical anatomy and physiology of the rectum and anus are discussed in their relationship to megalocolon.

3. Doubt is thrown on generally accepted methods of innervation of the rectum and anus.

4. The nervous control of the colon and rectum in Hirschsprung's disease as well as points of clinical and pathological importance is discussed.

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POST-SCRIPTUM.

CASE II (H.P.). The child was seen in September, 1947. He looked well and there was no abdominal distension. His father stated that during the past year he had had several attacks of severe abdominal pain associated with distension. Constipation had been troublesome. Opaque enema showed gross changes to be present still in the right half of the colon, but tone was good and emptying satisfactory.

It is not possible to say at present whether his attacks were due to small bowel obstruction or to the condition of the colon.

CASE I. M.S. was seen recently. His mother stated that the bowels worked daily with paraffin. On examination he appears to be a fit, normal boy.

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INDIRECT INGUINAL HERNIA: A CONTRAST BETWEEN THE SITES OF RECURRENCE AFTER THE SIMPLE AND AFTER THE PLASTIC OPERATION.[1]

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INTRODUCTION.

THIS paper deals only with indirect inguinal hernia. In the whole of surgery there is probably no event so disappointing as recurrence after an operation for ordinary indirect hernia. In the twenty years that have passed since I first started operating on my own patients with hernia I have had several such disappointments. It is only in recent times, however, that I have deliberately attempted by systematic investigation to get at the whole truth of the matter. This paper records this attempt. I must state at once that although, of course, I am still far from knowing the whole truth, the attempt has been a fruitful one. It has forced me to modify greatly my ideas on hernia. As a disciple of Hamilton Russell, I have always been a strong advocate of the simple operation involving little more than twisting, ligating and excising the sac. I am still a strong advocate of this operation, but I now think it does not go far enough. On the other hand, I have not confined my procedures to the simple operation. I have frequently, in certain types of case, used one or other of the extensive plastic procedures that from time to time have been recommended. My own experience with these operations, combined with what I have learned by a study of literature, leads me to the opinion that they go too far. Their use in surgery introduces a problem that very often need not be introduced at all.

When a surgeon commences operating on hernia, he does so in accordance with the ideas of the school in which he has been trained. It may be said that there are, in general, two schools of thought. According to the first, which owes its existence to the work of Bassini (1889), not only must the sac be removed, but in addition an attempt must be made to form a new canal. In the whole of surgery there is probably no other instance in which one man so completely dominated a particular field as Bassini did in hernia. His operation spread all over the world and was adopted in most teaching schools as the standard operation. It is still apparently the standard procedure, and in January, 1946, Turnbull[(1)] stated that it was the main procedure in use in Australia. It is worth while noting in passing that a study of Bassini's original article, as well as those of contemporary surgeons, such as Halsted, shows that in those days the usual type of hernia presenting for operation was large and well established.

The other school owes its existence to the work of Hamilton Russell.[(2)] In 1899 Hamilton Russell first put forward the "saccular theory". His theory led him to believe that if a hernia was due to a preformed sac, all that was necessary to cure it was to excise the sac. In his later years Hamilton Russell added to this teaching. He now said that one great advantage of removing the sac only was that the sphincter action of the muscles arching over the canal was not impaired. Hamilton Russell's experience with fractures had led him to think deeply on the subject of

[1] Read at the annual meeting of the Tasmanian Fellows of the Royal Australasian College of Surgeons on August 16, 1946. Accepted for publication on October 4, 1946.

muscles. This particular conception of sphincteric action, however, was introduced by Keith[3] in the course of an article specially written to refute Hamilton Russell's saccular theory. It is to be noted that Hamilton Russell was a surgeon in a children's hospital, so that his immediate practical experience bore out his theory.

It must be pointed out that there is a very big difference in the procedures of the two schools. Bassini's practice has been modified in many ways, but the general result of such operations is much the same and has been most strikingly described by Brandon:[4]

> In this group we are compelled to replace nature's active muscular control of the inguinal canal by a passive channel which must allow unimpeded passage to the spermatic cord but at the same time discourage the insinuating appeal of the hernial sac for an equal right of way.

The difference between the two schools might be brought out by calling one "the dynamic school" and the other "the passive school". Such a description would be more dramatic than correct, however. It is very well known that the cure of hernia depends primarily on the integrity of the fascia. If this fails, the most powerful muscles will not prevent the hernia from recurring. The muscles do play a most important part, however, in supporting the fascia, particularly during periods of strain. The simple school, therefore, depends on the passive fascia as well as on the active muscles. On the other hand, in the plastic operations it is the posterior wall only which is transformed into fascia. The powerful external oblique muscle still remains "active".

SECTION I: THE SIMPLE OPERATION AND ITS RECURRENCE RATE.

The study of hernia in Tasmania was greatly stimulated in 1926, when Hamilton Russell came for a week's post-graduate teaching. That pleasant and memorable week was recalled very vividly to me when, on going through the old histories for the purpose of this paper, I came across one in which under the heading "Surgeon" was my own name and under that of "Assistant" was "R. Hamilton Russell". As a matter of fact, Mr. Russell did the operation himself. All who saw him were impressed by his mastery of the operation, which seemed to be finished with a few strokes of the knife and of the finger. His method will be briefly described. In splitting the external oblique, he opened the external ring only if more room was necessary. After splitting the cremasteric muscle for the whole length of the canal, he seized the sac at about half-way between the two rings. He then dissected in a backward direction—that is, at right angles to the long axis of the sac—until he had opened up a small space between the sac and the cord. Making sure that the vas was out of the way, he cut the sac clean across and left behind the distal part. He then dissected the proximal part until the neck was completely separated from the cord, which was pushed down into the pelvis. The next step was an important one. Hamilton Russell always maintained that it was necessary, for the cure of this type of hernia, to remove the sac only. This next step of his operation, however, has to be regarded as a plastic procedure involving the neck of the sac. First of all the sac was completely freed from all the tissues in the neighbourhood. Then, after having applied artery forceps to the mouth of the cut sac and after having inspected its interior, he twisted the sac by means of the artery forceps. When it was tightly twisted he tied a ligature of chromicized catgut number 2 as close to the peritoneal cavity as possible. He did not like transfixion sutures. He then cut the sac off about 1·5 centimetres beyond the ligature and let it drop back. According to Treves,[5] this method of dealing with the sac was introduced to surgery by Charles Ball (1883).

There can be no doubt about its importance. In the first place it draws together the transversalis fascia. In the second place, unless it is made, about half the mouth of the hernia is unguarded by the conjoined muscle in the resting position. After the twist, however, the sac, in the great majority of cases, slides up far beneath the conjoined muscle. I have made observations as to whether there is any difference according as the twist is made in a clockwise or an anticlockwise direction and there is no difference. This is a suitable time to record another observation which I have made and which may have a bearing on recurrence after this type of operation. In 100 cases I have taken special note whether the sac always slid under cover as the result of the twist. In five cases it did not, but remained uncovered by the conjoined muscle in the resting position.

There is one other important point in regard to the clearing of the neck. As a resident medical officer I was taught by Sir Alan Newton to dissect on the medial side of the sac only until a piece of canary-coloured extraperitoneal fat came into view. His reason was that this fat indicated the near presence of the bladder. There is another reason for the preservation of this fat. This reason will become apparent if the surgeon, eager to separate the sac as high as possible, pushes the fat away. What happens is that at once all the adjacent peritoneum balloons out, and if the neck of the sac at first admitted one finger, say, it will now admit three. The fat is kept in position by fascia which supports the surrounding peritoneum, and this fascia must be kept intact.

The external oblique and the skin are closed in the ordinary way.

I will now refer to the recurrence rate after the simple operation. Before doing so, however, I should like to quote two well-known authorities in reference to recurrence rates in general. Ogilvie[6] states:

> It may be said that close upon 100% of cures should be expected after operations in children, and about 95% after operation in adults.

In the course of a critical review published in 1943 Edwards[7] writes:

> Recurrence after hernia operations is extremely common, and we must expect that, whatever results the expert may claim after his operation, in his own hands, at least 12 per cent of patients operated on for indirect hernia in this country (Great Britain) suffer recurrence.

Two series of cases operated on at the Launceston General Hospital will be presented. The first series includes all cases in which the Hamilton Russell operation was performed between 1926 and 1941. The operations were performed by several different surgeons, including resident medical officers. The follow-up was done only recently and was, for the most part, by correspondence. The second series consists of those operations done by myself or by resident medical officers with myself as assistant between January, 1942, and December, 1945. There has been a close personal follow-up of the cases in this series. The patients have been asked to report at six-monthly intervals and I have personally examined all of them during the last few months. The details are shown in the accompanying tables.

Series I (several surgeons). Between the years 1926 and 1942, 501 operations for primary hernia were performed at the Launceston General Hospital. Of these, 275 were done by the Hamilton Russell method. Of these 275, 150 were performed by myself or by resident medical officers whom I had trained to do the operation. I did not exclude any patient on the grounds of age or of size of the hernia. On the other hand, my colleagues did not use this method for very large hernias, but I have not been able to discover exactly how many were thus excluded. In the great majority of these 275 cases ether was the anæsthetic. The patients stayed in bed for from ten to twelve days. They returned to work in from six to eight weeks. Of the

275 patients, 132 have been traced. The number of recurrences is 16. It is obviously impossible to give a correct percentage of recurrence for this series. The lowest possible recurrence rate is 5·9%—that is to say, this would be the recurrence rate if it was certain that there were no more recurrences among the 143 patients who cannot be traced. This can perhaps be expressed by saying that the recurrence rate is "5·9% *plus*".

Series II (personal). Since 1942 most patients with indirect hernia have been under my own care and with some modifications the operation has been carried out on 154 occasions. From this group I have excluded 31 hernias on the grounds of being too large for the simple operation. This means that I considered 83% of hernias suitable for the simple operation.

The first modification was as follows. The neck of the sac was transplanted, but, instead of the tying sutures being used, as is usual, two thin sutures were made from the sac on the distal side of the tie. It was noticed where the sac neck came to rest when it was released, and at that

TABLE I.

Age Groups in the Two Series of Patients.

Series.	Number 1 to 10 Years.	Number 10 to 20 Years.	Number 20 to 30 Years.	Number 30 to 40 Years.	Number 40 to 50 Years.	Number 50 to 60 Years.	Number 60 to 70 Years.	Number Over 70 Years.
1	41	31	55	40	26	25	19	5
2	23	21	21	14	25	21	12	5

TABLE II.

Sex Groups in the Two Series of Patients.

Series.	Number of Male Patients.	Number of Female Patients.
1	223	19
2	138	4

TABLE III.

Occupation of Patients in the Two Series.

Series.	Percentage of Adults of Sedentary Occupation.
1	4·0
2	4·2

TABLE IV.

Showing Number of Patients and Duration of Symptoms Before Operation in the Two Series.

Series.	Number Up to 6 Months.	Number 6 to 12 Months.	Number 1 to 2 Years.	Number 2 to 3 Years.	Number 3 to 4 Years.	Number 4 to 5 Years.	Number 5 to 10 Years.	Number Over 10 Years.
1	85	46	32	19	15	11	33	34
2	73	21	10	8	7	—	23	12

TABLE V.

Recurrence after the Simple Operation.

(All patients are male.)

Number.	Age. (Years.)	Occupation.	Side.	Duration of Symptoms.	Notes on Hernia (where given).	Anæsthetic.	Length of Time before Recurrence.	Second Operation.	Type of Recurrence.
				Series I (Several Surgeons).					
1	58	Farmer.	Left.	Years.	Appears on standing.	Ether.	Unknown.	Yes.	Indirect. (Another hospital.)
2	11 months	Baby.	Right.	Since birth.	Strangulated.	Ether.	Soon after operation.	Yes.	Indirect.
3	34	Timberworker.	Left.	17 years.	Descending to scrotum.	Ether.	Five years.	Yes.	Direct. "Tubular."
4	2½	—	Left.	1½ years.	Comes to external ring.	Ether.	Soon after operation.	Yes.	Indirect.
5	20	Labourer.	Right.	3 months.	Small.	Ether.	Unknown.	Yes.	Indirect. (Another hospital.)
6	66	Taxi driver.	Right.	1½ years.	Large, strangulated.	Ether.	Three months.	Yes.	Indirect.
7	30	Artisan.	Right.	Some months.	Strangulated.	Ether.	Several years.	Yes.	Indirect.
8	60	Pastrycook.	Right.	12 months.	Small.	Ether.	Soon after operation.	Yes.	Indirect.
9	22	Labourer.	Left.	3½ years.	Descending to scrotum.	Ether.	One year.	Yes.	Indirect.
10	18	Labourer.	Right.	6 months.	Small.	Ether.	Five months.	Yes.	Indirect.
11	30	Labourer.	Right.	3 days.	Small.	Local.	Five years.	Yes.	Indirect.
12	20	Labourer.	Right.	7 days.	Descends to scrotum.	Ether.	22 months.	Yes.	Indirect.
13	38	Labourer.	Bilateral.	Left: Since birth. Right: 6 months.	Both evident.	Ether.	Unknown. Left recurred.	No.	Indirect. (Examined elsewhere.)
14	42	Labourer.	Right.	3 months.	Hernia present.	Ether.	Unknown.	Yes.	Indirect. (Another hospital.)
15	43	Pensioner.	Left.	9 months.	Hernia present.	Ether.	One year.	No.	Indirect.
16	20	Labourer.	Left.	3 years.	Large, going into scrotum.	Ether.	One year.	Yes.	Indirect.
				Series II (Personal).					
17	47	Lorry driver.	Bilateral.	Right: Since childhood.	Double hernia present.	Ether.	Three years. Left recurred.	No.	Indirect.
18	25	Turner.	Right.	Left: 18 months. 6 days.	Small.	Ether.	One year.	Yes.	Indirect.
19	58	Car driver.	Right.	4 months.	Large.	Spinal.	Within one year.	Yes.	Indirect.
20	40	Teacher.	Right.	Since 2 years old.	Moderate.	Spinal.	18 months.	Yes.	Indirect.
21	19	Farmhand.	Bilateral.	12 months.	Left: To scrotum. Right: To external ring.	Ether.	One year.	No.	Indirect.

spot, by means of a Gallie's needle, the two hernia sac strips were taken separately through all the abdominal muscles so that they emerged about 1·0 centimetre from each other. Each was then sutured to the outer surface of the external oblique tendon, and after the two strips had been crossed, to each other. In this way the neck of the sac was gently drawn against the under surface of the transversus muscle (Figure I).

The other modification was adopted in consequence of a study of the results of a large series of cases carried out by Shelley.[8] In most of these cases operation had been performed by a modification of Bassini's method. Shelley divided his recurrences into two groups, firstly direct, and secondly indirect. It struck me that the percentage of indirect recurrences was very low, and this suggested that there might be something about the Bassini operation which was useful in preventing indirect recurrences. It seemed possible that this something was the acute kink produced in the cord by its being undersewn with the conjoined muscle. The recurrent indirect hernia always escapes in the same direction in which the original sac lay. The kinking manœuvre seemed to close this space. An attempt was made to imitate this kink by sewing under the outer end of the cord not the conjoined muscle but the cremasteric muscle. This manœuvre was carried out in 60 cases. However, it apparently did no good, as it was carried out in all those cases in which recurrence took place. The fault, however, may have lain in the inefficiency of the method. The theory may be correct (Figure II).

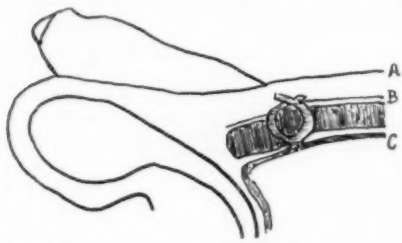


FIGURE I. Showing how the twisted and tied neck of the sac is drawn away from the internal ring by two strips cut from the sac and passed separately through the abdominal muscles and then sutured together. A = skin, B = external oblique, C = peritoneum.

In all these 154 cases the sac was tied after transfixion with a figure-of-eight suture of number 1 silk. Fine silk was used for the other ties and ligatures. Ether was used as the anæsthetic agent in 96 cases and spinal anæsthesia in the remainder. Spinal anæsthesia was used because there is less vomiting after it. All these patients were kept in bed for fifteen days. They were advised not to return to work until two months from the date of operation. There were 142 patients in this series. In 12 cases the hernia was bilateral, so that 154 operations have been done in all. The number of recurrences is five, which gives a percentage of 3·2.

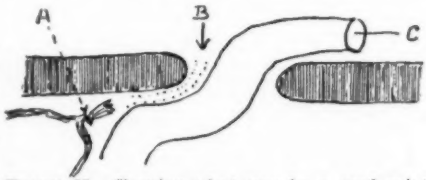


FIGURE II. Showing what may be a good point in the Bassini operation. The undersewing of the cord causes an acute kink in the cord, which forces it against the muscle in the area formerly occupied by the neck of the sac. This area has been "rawed" by dissection and the two opposing surfaces may unite, thus helping to close the space through which the recurrence appears. The dotted lines show the rawed area. A = stump of sac, B = raw area, C = cord.

SECTION II: THE SITES OF RECURRENCE.

By far and away the most unsatisfactory feature of the literature of hernia is the scant attention that is paid to the correlation between the type of operation and the exact anatomical site of recurrence. From the study of the literature up until 1942, however, one fact does emerge, and that is that the main teaching has been that the recurrence most to be expected is the direct recurrence. Willys Andrews,[9] reviewing the year's

work for "The Medical Annual" of 1920, states: "Practically all the recurrences are in cases in which wound infection takes place and most of them are direct in type, emerging just above the pubic spine." Max Page[10] (1924), after quoting a large number of figures from German, American and English sources, states:

> Although it is of interest to discover the exact nature of the recurrence after an operation for indirect hernia, I find it difficult from published records to come to any definite conclusion on the subject. Certainly the majority of recurrences are not properly oblique or into the remains of the original sac. Block's figures suggest that the majority of recurrences are internal direct hernias, and that is consistent with my observations (from a clinical standpoint) in a group of policemen.

Rendle Short,[11] reviewing the year's work in "The Medical Annual" of 1932 and 1933, rebukes certain surgeons for paying special attention to the internal ring with the words: "But the main recurrence is direct." Ogilvie[9] (1937) says the same thing. In a symposium on hernia published in the *Annals of Surgery* for 1942 one or two of the speakers mentioned indirect recurrences, but the majority were agreed that the main recurrence was direct.

I shall now turn to the analysis of the recurrences of the two series of cases operated on by the simple method. Something very striking emerges at once. Of the 21 recurrences, all, with one exception, were not direct, but indirect. In those cases in which operation was again performed, it was found that the new sac reproduced exactly the anatomical position of the sac that had previously been removed. In fact, if the surgeon had not known that the first sac had been removed, he would have been justified in thinking that it had never been touched at all. The one exception was a direct hernia of the Ogilvie "tubular" type, associated, as have been the other sacs of this type that I have seen, with a high insertion of the conjoined muscle and with a very tough *fascia transversalis*. It occurred five years after the primary operation. I do not think that it was a true recurrence. It was probably a new hernia. On examining again the articles from which I have just quoted, I found that in each case the author had based his teaching on a series of patients operated on by one of the plastic methods. It might seem, then, that there are two types of recurrence, one indirect for the simple operation and the other direct for the plastic operation. This is not the case, however. The articles published by Shelley[8] (1940), Edwards[7] (1943) and Patrick[12] (1944) make quite plain the state of affairs as far as the plastic operation is concerned. There are two types of recurrence after plastic operations, one indirect, of the same type as has been described as occurring after the simple operation, and the other direct.

I have made an attempt to find other articles describing the site of recurrence after the simple operation. Reports of results have been published by Holman,[13] Max Page,[10] Lameris,[14] and Turner and Eckhoff.[15] None, however, states the exact site of recurrence. Hull[16] states that the recurrence is at the internal ring or near it. Brandon[4] states:

> When recurrence does take place the sac is an oblique one and has resulted from a technical error on the part of the surgeon.

Neither of these two authors, however, produced their evidence. So far as the evidence goes, however, I would ask you to accept the fact that the only type of recurrence after the simple operation is the indirect one.

I should like now to compare my own series of cases with a series of cases reported by Shelley. Shelley's patients were operated on by a modification of Bassini's method. If the more difficult cases are excluded, as was done in my own series, there were 1,138 cases in all. Of these, 74 hernias recurred, giving a 6·5% recurrence rate. The interesting figures

come, however, when the recurrences are divided into "indirect" and "direct". There were 32 indirect recurrences (2·8%) and 42 direct recurrences (3·7%).

It will be seen that his indirect recurrence rate (2·8%) is much the same as in my series (3·2%); but whereas in my series there were no direct recurrences, his rate was 3·7%. These figures would be more impressive if my series numbered 1,154 instead of only 154.

It is obvious that this matter requires more study. There is in fact no problem connected with hernia that requires more attention. If after such study the statements made above are shown to be correct, their implications are obvious. As was stated in the introduction, the plastic operations have introduced to surgery a problem that should not be there—the problem of the direct recurrence.

SECTION III: THE CAUSES OF RECURRENCE.

The Direct Recurrence.

In regard to direct recurrence there are two schools of thought.

1. The first school maintains that this recurrence is due to the damage done to the structures forming the posterior wall of the canal by the plastic procedure carried out to cure the hernia. This is best expressed in the words of Edmund Andrews:[17]

> It is very striking that in every series of recurrences, recurrence takes place in the majority of cases at the pubic end of the canal and not at the internal ring, where the hernia was in the first place. It is only fair to ask by what right we call these recurrences. There was no hernia in this position before and I believe that we are actually causing hernias to appear in the lower end of the canal by too much stitching of layers which are intact and have up to date prevented any herniation at that point.

Hamilton Russell also took this view. He was always threatening to write a book on "Methods of Escaping from Difficulties Created by Surgeons" and the direct recurrence was his favourite illustration.

2. For at least sixty years one of the main explanations of the direct recurrence has been that it is due to the presence of a direct sac which was overlooked at the first operation. No very convincing evidence was ever brought forward to support this contention. In 1926, however, McQueeney[18] published an article in which he claimed that in a series of 129 cases he had found sacs present in nine cases. In 1939 Ramos and Burton[19] published an article in which they maintained that over the age of thirty-five years single indirect sacs were rarities. They stated that, if searched for, there were usually found, medial to the inferior epigastric artery, locules and diverticuli. They stated that in recurrent hernias the rate of direct to indirect sacs was 8 to 1, whereas in primary hernia the rate of direct to indirect sacs was 1 to 5. They maintained that recurrence was due to non-recognition of the direct portion of the sac and failure to remove it at the initial operation.

The first criticism one levels at this work of Ramos and Burton is that it would appear that most of these direct sacs were not discovered by clinical means, but by digital examination at the time of operation. In other words, no direct hernia was seen before operation, but it was inferred by examination during operation that a direct hernia would appear unless something was done to prevent it. It is doubtful if this is sound reasoning. It is easy to imagine that a diverticulum in its early stages might not be obvious to external examination, but surely the usual bulge of a direct hernia would be obvious. If a direct hernia is not present before operation, how is it possible to foretell that it will occur in the future? I am reminded of three patients whom I saw five years ago within the space of a month. They

all had indirect hernias and at operation everyone agreed that the muscles and fascia forming the posterior wall looked and felt very weak. It seemed certain that direct hernias would occur. Nothing more than a simple operation was done and there has been no recurrence of the original hernias and no appearance of direct hernias.

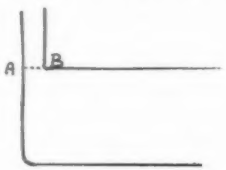
I have always made a habit of examining the posterior wall with my finger during operation, and so far I have not found the sacs described. In none of the cases that I have examined has a direct hernia appeared since the operation for indirect hernia, unless in addition to removing the sac I at the same time carried out a plastic repair involving the posterior wall.

It would seem essential that the surgeon should make up his mind which of these two theories he believes. One is always guided by one's own experience and my belief is that the direct recurrences in the great majority of cases are due to operative interference. The combination of muscle and fascia which makes up the posterior wall is extremely powerful, but it is at the same time very delicately set. When a surgeon is tempted to interfere with this mechanism he should, in imagination, see written across the posterior wall the famous motto of heraldry: *"Nemo me impune lacessit."*

The Indirect Recurrence.

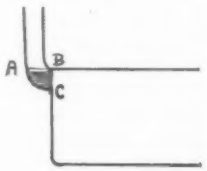
The following points are noteworthy in connexion with the indirect recurrence.

1. The critical observation in this regard is that made by Taylor,[20] who, after having studied Halsted's series of cases, stated that recurrence never occurred if the testis and cord were removed. I have removed the testis and cord from twelve men with very large hernias, and eleven undescended testes associated with hernias. Six of the twelve and seven of the eleven have been followed up and there have been no recurrences.



III A

FIGURE IIIA.



III B

FIGURE IIIB.

Figure IIIA illustrates the wrong impression as to how the sac emerges from the peritoneal cavity. Figure IIIB shows how it actually does emerge. If the sac is removed at B the shaded area between AB and BC will be left behind.

The cord is a pulsatile organ and, moreover, being attached to the testis, it is constantly in movement. This means that at its point of origin there is always a small space round it. It is probable, therefore, that it will always be impossible to prevent indirect recurrences.

2. It is very interesting to note that the plastic operations do not alter the percentage of indirect recurrences.

3. Sluggish muscles may be one of the causes of recurrence. So far I have done nothing in this regard, but I intend in future to follow the example of Edwards and Patrick and to have muscle exercises carried out both before and after operation.

4. The following may be faults in the handling of the sac and surrounding tissues. (*a*) It is usually stated—often contemptuously—that the cause of indirect recurrence is failure to remove the whole sac. I am quite certain that in all my cases the whole sac has been removed, but there have been recurrences nevertheless. There is one anatomical reason why at times the sac may not be completely removed. I used to think that the sac came from

the peritoneal cavity in the manner shown in Figure IIIA. In this case the mouth of the sac would be in the plane AB. Actually the sac comes off in the manner shown in Figure IIIB and its mouth is in the plane BC. If, therefore, the sac is removed at the level AB, a small amount of sac will be left behind between AB and BC. This is not likely to happen if Ball's twist is used. It must be remembered that, using the usual technique, no surgeon completely removes the sac. He ties his ligature and relies on Nature to do the rest. If the ligature dissolves or breaks prematurely, it is obvious that the beginnings of a new sac are present. (*b*) I have already recorded the observation that after Ball's manœuvre the sac fails to slide under cover in 5% of cases. I took pains in all cases comprising the last series to transplant the neck of the sac. This, however, did not prevent recurrences. (*c*) To carry out Ball's manœuvre it is necessary to undercut the muscles on the superior and lateral sides of the neck of the sac. I know from bitter experience that it is dangerous to undercut the muscles at the inner side of the canal. Does the same thing apply at the outer end? Would it not be better to separate the sac and then to remove it without undercutting, and perhaps at the same time to add some local repair? Only carrying out a series of cases would settle this question.

After all the evidence has been produced and after all the suggestions have been considered, it has to be admitted that the cause of indirect recurrence is obscure, except as far as the presence of the cord is concerned.

SECTION IV: THE CHOICE OF OPERATION.

The main purpose of this paper is expressed in this section. I feel that a great deal of alteration is needed in the surgery of hernia as at present practised.

As far as the simple operation is concerned, I think there are too many recurrences. A recurrence rate of 3·2% looks little on paper, but it is a great deal when thought of in terms of the individual patient. The patient has to face two long periods of inactivity. The surgeon has to face a most difficult operation, with the chance of further lack of success. Moreover, there is this point to be made: that it is impossible to say in an individual case whether there is likely to be a recurrence or not. As a glance at the list of recurrences will show, the fact that a patient is young and has just acquired a hernia does not render him immune from recurrence. Therefore it would seem logical to strengthen this operation in every case, the early as well as the late. The question is: "How should it be strengthened?" There are two courses of action open. One is to do what I did with the larger hernias—to use one or other of the many plastic procedures. The other is to use a strengthening operation which is purely local and which involves no interference with that part of the posterior wall which remains intact.

I have not the faintest shadow of doubt which type of procedure should be used—it should be the local strengthening operation. I do not wish to give my experiences with the plastic operations in detail, as there is no point in doing so. Their history is written only too plainly in the literature. I should like, however, to quote one case in illustration of my thesis: that the direct recurrence after the plastic operation is not a recurrence at all—it is a new hernia produced by the operation.

A man of thirty-three years, a labourer, complained of a bilateral hernia which had been present on both sides for three years. A large sac was present on both sides. Not more than half the posterior wall of the canals was occupied by the hernias. The muscles appeared to be in excellent condition. Gallie's operation was performed on both sides. Within six months there was a bilateral recurrence. At the next operation it was found that on each side there were now two hernias, a

recurrence of the original indirect one and, in addition, a separate direct hernia coming through just lateral to the insertion of the conjoined tendon. Where the muscles had previously looked to be in good condition there were now no muscles to be seen at all. Instead there was a confused mass of scar tissue. The hernias were again repaired by the Gallie method. Three of them have remained apparently cured, but there has been a recurrence of the right direct hernia, which is now large and diffuse. The patient is disgruntled.

I wish to make two points in regard to this case. Firstly, in my own experience this is the commonest type of large hernia. Although the sac is large there is still an appreciable amount of posterior wall left and the muscles are in good order. The advanced type, with the sac occupying the whole posterior wall and with the muscles atrophied, is now happily rare. The second point is that a Gallie's operation was chosen as an illustration because, according to the reports, it is one of the most successful of the methods of plastic repair. Similar types of recurrence can be found easily in the literature following all those procedures which involve interference with the posterior wall. The Bassini operation is a common offender. Of the 1,138 patients reported by Shelley and who, apparently, did not have very big indirect hernias to start with, 42 returned with direct "recurrences".

The extraordinary thing is that all over the world surgeons are apparently accepting the direct recurrence as being inevitable. It is very difficult to find any reasonable explanation for their attitude. It has been shown that 80% of patients presenting nowadays with hernia are suitable for a simple operation and that the operation will produce a reasonably low recurrence rate. In this class of case there is not the slightest excuse for using a plastic operation. In the larger cases it has yet to be shown that the plastic operations will greatly reduce the number of true or indirect recurrences and at the same time they introduce a new and entirely unnecessary complication—the direct "recurrence". The whole affair would seem to be a classical instance of surgical loose thinking on a large scale.

So far as my own practice is concerned I am abandoning the large plastic repairs except in the rare very advanced cases and except, of course, in those cases in which the indirect hernia is associated with a direct hernia (whose presence is determinable by ordinary means before operation). My belief is that all the energy and ingenuity that have gone into the devising of these plastic procedures involving muscle should be diverted to the devising of a plastic procedure that does not involve muscle.

I shall now attempt to state the principles on which such an attempt should proceed. First of all the two cardinal observations will be restated.

1. If a simple operation is performed the recurrence reproduces exactly the original relationship to the cord.

2. If the cord is removed recurrence is unknown.

It is very obvious that what is required is the presence of a strong fascial barrier between the transversalis fascia layer and the commencement of the cord. To be effective such a fascial barrier would have to pass down below the level of Poupart's ligament and be tucked in round the pelvic fascia in the same way that a blanket is tucked in round the end of a mattress. The present almost universal habit of sewing the new tissue onto Poupart's ligament is equivalent to sewing the blanket onto the rail at the end of the bed. The new fascia will have to protect the whole of the area of transversalis fascia that is exposed by the operation, as it is not known through what part of this exposed area the new sac will come. The new fascia will have to be applied in such a way that when the abdomen is under strain there will be no risk of differential pressure—that is, the new fascia must be able to take part in the normal inguinal bulge (Figure IV).

The technical difficulties of such a procedure are obvious. The great barrier to the performance of such an operation is the presence of the large vessels just beneath the area of operation. Nevertheless it should be possible to overcome these difficulties. I had intended to work out the operation, using a rectangle of skin with long tails attached to each corner. The reason I have not done so is that I have been very much struck with the success of another procedure, which I shall describe in a moment. Before leaving the question of the formation of a fibrous barrier, however, I should like to refer to the use of sclerosing solutions for the purpose of creating new fibrous tissue. The use of such solutions is common in the treatment of hæmorrhoids. It is very well known, moreover, that some hernias have been cured by the method of injection alone. It would seem logical to make use of these solutions when we have the canal opened and the anatomy is plain to see. At present I am using these solutions in alternate cases. Care is taken not to enter the peritoneal cavity and injections are made into the whole of the area of transversalis fascia that is exposed. A small amount is left lying in the space formerly occupied by the neck of the sac. Not more than three cubic centimetres of carbolic acid in olive oil are being used in each case. Hydrocele and atrophy of the testes are being watched for.

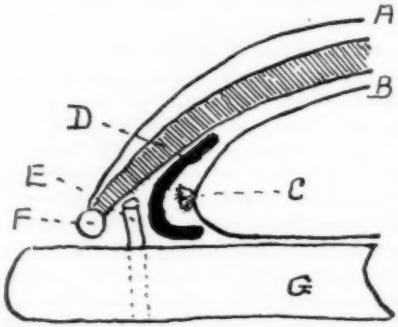


FIGURE IV. The thick black line shows the position of the proposed graft of skin or fascia inserted in such a way that it completely cuts off the neck of the sac and the surrounding transversalis fascia from the origin of the cord, in close relation to which a recurrence always develops. When such a graft is sewn to the inguinal ligament a weak spot is left. A = external oblique, B = peritoneum, C = neck of sac, D = insert of fascia on skin, E = vas, F = inguinal ligament, G = iliac artery.

I now wish to draw your attention to another possible method of strengthening the simple operation without touching the muscles. This is nothing more or less than inversion of the sac.

In 1935 I found myself confronted with a large sac in a man of thirty-five. It had been present for many years and was completely lined, though not filled, with omentum. I was at a loss as to what to do, as I did not wish to cut the omentum in such a way that a raw surface would be left inside the peritoneal cavity. Finally, after freeing it in the usual way, I completely inverted the sac and sewed up the mouth. I intended to go on and do an extensive repair, but at this stage the anæsthetist asked me to hurry (spinal anæsthetic was being used). Consequently all I did was to overlap the two flaps of the external oblique aponeurosis and to close the wound. I thought this hernia would recur. A year passed. The patient had long since gone back to hard work as a cabinet-maker. Two years passed and still nothing happened. Nothing has happened since.

Since then I have always used this method in sliding hernias. Excluding cases done in the last four years, I now find that I have done the operation in nine other cases. This makes ten in all; most of the subjects were patients in my former private practice. All these patients were males between the ages of thirty-four and fifty-five years. In all, the hernial sacs were large, the mouths admitting four bunched fingers. In all there still remained medial to the mouth of the sac an appreciable amount of posterior wall. In all the muscles appeared to be in excellent condition. In two of the cases the sac was lined, though not filled, with omentum. In the rest there were present varying amounts of large bowel and omentum. Bladder was not recognized. In the first five I overlapped the flaps of the external oblique aponeurosis. In the last five I injected carbolic in olive oil into the tissues round the mouth of the inverted sac after it had been closed. Spinal

anæsthetic was used in all cases. All patients remained in bed for three weeks and were advised not to return to work for three months. Three of the patients were sedentary workers, seven were in active occupations. There have been no recurrences.

The operation is done as follows. In freeing the sac it is very important that there should be as little trauma as possible to the peritoneum lining the sac. Therefore artery forceps are not used to grasp it. In order to get a long enough sac for the purpose it is necessary to follow the sac as far down as the external ring. After the sac has been freed in the usual way it is either opened at its extreme end or, if it has been cut across, the cut ends are held apart with forceps. The contents are now inspected. Judgement has to be used in the matter of not acutely kinking bowel. So that raw tissue will not present to the peritoneal cavity a ligature is now tied round the sac just proximal to where it was cut. Four stay sutures are next inserted round the neck of the sac, one superior, one inferior, one lateral, and one medial. Whilst these sutures hold the mouth of the sac apart the sac is inverted through it. The superior and inferior sutures are now removed. Whilst the other two sutures are held taut the mouth of the inverted sac is closed with several interrupted sutures of fine silk. It is

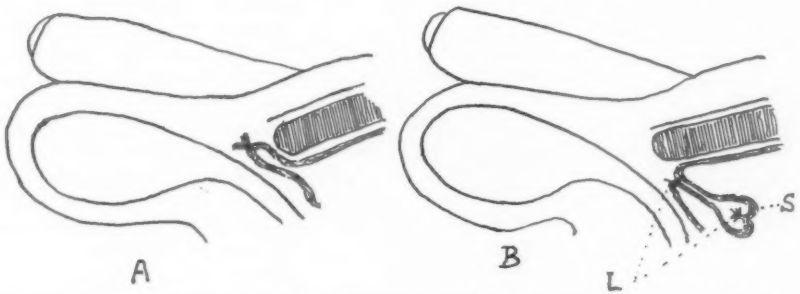


FIGURE V. Showing the method of inversion used for sliding hernias. *A* is before inversion. The sac has been opened for inspection and then closed with a ligature so that no raw surface presents to the peritoneum. *B* is after inversion. The mouth of the inverted sac is closed with interrupted sutures. A pursestring suture should not be used. *S* = inverted sac, *L* = ligatures.

very important not to use a pursestring suture, as this would strangle the sac. It is vital that it should live. In these large hernias there is no difficulty about the sutures cutting out as the transversalis fascia is thick and heavy. One of the most pleasing features of the operation is the efficient manner in which the transversalis fascia can be got together. Also, of course, no part of the sac is left projecting, as is the case in the ordinary operation. The external oblique flaps may be overlapped or not, according to the judgement of the surgeon (Figure V).

I now wish to take particular pains in pointing out that the strength of this inverted sac lies not only in the sutured mouth. The two opposing surfaces of the inverted sac have just been "rawed" by the process of dissecting the sac from its bed. It is supposed, if the sac lives, that these surfaces would become firmly united by the process of inflammation. I hold in my hand an ordinary rubber glove. You will see that two of its fingers are inverted. I now fill the glove with air. One finger is now completely reinverted but the other is not. The reason that this glove finger is not reinverted is that, before it was inverted, its surface was covered with glue. Its two inner surfaces have become adherent to each other.

Encouraged by the success of these cases I have for some time been inverting the sac in nearly all cases and excluding none on the score of size. The operation has to be done somewhat differently when there is an ordinary type of sac. In these the tissue round the mouth of the sac is not thick enough to hold sutures securely and there is a danger of the sac being forced out again. For this reason it is safer to take the sac through the muscle of the abdominal wall. This is done by holding the mouth of the sac open with artery forceps. After the patient has been put into Trendelenburg's position a MacCormick dissector is passed through the sac and when its end reaches a spot 2·5 centimetres lateral and slightly superior to the internal ring it is forced through the transversus and internal oblique muscles. It may be taken through the extreme oblique as well, but this is a little bit more difficult. The dissector is pushed through so that the hole in its other end is opposite the end of the sac. This end is now sutured to the dissector and the sac is pulled through the muscle. Great care has to be taken to see that the sac is completely inverted. With the idea of closing its mouth the sac may be gently twisted, but not to the extent of strangling it. A tunnel is now made beneath the external oblique muscle in an outward direction. A silk suture is placed through the end of the sac and the two ends are taken separately through the tunnel and then through the external oblique and the skin and are tied together on the surface (Figure VI). Two stitches hold the sac to the muscles as it passes through. There are two disadvantages to this operation. One is that a hole has to be made in the parietal peritoneum. The other, which is theoretical, is that it may establish an area of differential pressure. When the operation is done by the first method the transversalis fascia can take part in the normal inguinal bulge during periods of strain. In the second case it cannot. I find that I have performed this operation on forty-two occasions. Twenty-nine have been done for over a period of six months. So far there have been no recurrences. This means little, of course, and some years will have to elapse before any conclusions can be drawn.

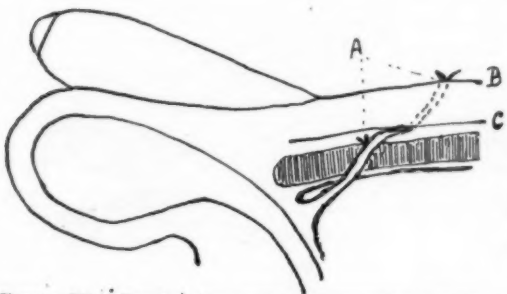


FIGURE VI. Showing the method of inversion for the ordinary type of sac. Two sutures hold the sac to the internal oblique and one suture from the end of the sac is passed through the skin and tied. The sac may be gently twisted after inversion. A = ligatures, B = skin, C = external oblique.

So far, except for using a sclerosing solution in alternate cases, I have not used any extra method of repair. It is very obvious, however, that this method is very suitable for use in combination with such a local strengthening as has already been described. Reference to the literature shows that the method of inversion is not new in the history of hernia. According to Collins,[24] Kocher was the first to practise it. He published reports of 76 cases with two recurrences. The next reference I can find to it is Beckman[21] in 1912. He recommended the method when the abdomen had been opened for some other reason and a small inguinal or femoral sac was found. In 1941 Buckley[22] reported that he had used the method in 30 cases of femoral hernia. He had not followed the patients up, but none had returned. In 1930 Bevan[23] described the method as used by him in cases of sliding hernia, but did not report a series of cases. Willis[25] and Collins[24] have also

described the method of taking the sac into the abdominal wall. Both these authors cut the sac off short. This may be a mistake. It has already been described how the adhesion of the sac's inner walls gives strength. So far, with the exception of Kocher's series, no series of cases has been published.

SUMMARY.

1. Two series of cases of indirect inguinal hernia operated on by the method of R. Hamilton Russell are reported. The second of these series consisted of 154 operations personally conducted. There was a close personal follow-up. The recurrence rate in this last series was 3·2%. As 31 cases of large hernia were excluded from this series, it is thought that the recurrence rate was too high.

2. An analysis of the 20 recurrences occurring after both series showed that 19 were indirect in type. In those operated on it was found that the new sac reproduced the original one exactly, as far as site was concerned. The one direct recurrence occurred five years after the previous operation and was of the Ogilvie "tubular" type. It is thought that this was a new hernia. The state of affairs described above is contrasted with what obtains after the plastic operations involving gross interference with the muscles surrounding the inguinal canal. After these operations not only are there indirect recurrences, but there are also direct recurrences.

3. It is suggested that, in the great majority of cases, these direct recurrences are due not to the presence of an overlooked sac, but to the operative interference with the posterior wall of the canal.

4. Because of the reasons given above it is thought, firstly, that the simple operation should be strengthened and, secondly, that, except for certain types of advanced hernia, the plastic operations should be abandoned altogether. It is suggested that a new operation be devised which has as its main principle the establishment of a strong sheet of fascia between the exposed transversalis fascia and the origin of the cord. Part of the procedure would be reeducation of the muscles.

5. Two additional methods are described, to be used either alone or as adjuncts to other methods. (*a*) The injection of sclerosing solutions during operation. (*b*) Inversion of the sac. Ten large sliding hernias treated by this method are described. The method used in ordinary cases is also described.

ACKNOWLEDGEMENTS.

I am much indebted to Dr. Gaha, Dr. Lincoln, Dr. Ferris and Dr. Walker for letters about patients; to the secretary and librarian of the Royal Australasian College of Surgeons for their usual enthusiasm; to my secretary and her two assistants for their hard and thorough work on the records.

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Surgery in Other Countries.

[In this column will be published short résumés of articles likely to be of practical value from Journals published in other countries and not readily accessible to surgeons in Australia and New Zealand.]

THE KIRSCHNER WIRE AS AN INTRAMEDULLARY SPLINT.

L. Tavernier: *"Pseudarthroses avec perte de substance osseuse traitées par greffes souples sur broches métalliques intra-médullaires", Lyon chirurgical,* Volume xli, 1946, page 545.

P. Suire and P. Thobois: *"Sur l'embrochage par broche de Kirschner dans le traitement des fractures de la clavicule", Lyon chirurgical,* Volume xli, 1946, page 552.

In many cases of pseudarthrosis with loss of bony tissue, particularly in the bones of the forearm, great difficulty is often experienced in applying any form of graft which will maintain the fragments in satisfactory position. This applies equally to rigid cortical and to flexible cancellous grafts. The methods discussed in Tavernier's paper are put forward to meet this difficulty.

The bone ends, being exposed, are cleared by rugine for a distance sufficient to give good forceps control of them and to allow of the application of a graft 3·0 to 4·0 centimetres long. All cicatricial tissue is resected and a good vascular bed is assured for the graft. The medullary canal of each fragment is opened and a small drill is bored into and through the dense bony tissue, which nearly always closes in the ends of the cavity. A Kirschner wire is then introduced into the medullary canal through the open end of whichever fragment appears most suitable from the point of view of a convenient point of exit for the wire. In the ulna, for instance, this is the upper fragment, the wire emerging conveniently through the olecranon and the overlying skin. If neither fragment offers such a choice the wire is brought out through an oblique drill hole at the selected point, the end of the wire being guided into the drill hole by means of a small gouge. The wire, having emerged from the bone, is withdrawn until its other end engages in the medullary canal of the other fragment, when it is sent down it to the full length possible. Osteo-periosteal grafts prepared from the surface of the tibia are then placed round the wire in the gap between the fragments, the bone surface lying towards the wire, and are fixed in place by catgut ligatures. After closure of the wound a light plaster is worn for a month.

The author supports his advocacy of this method by three impressive cases and he warmly recommends the procedure as being one equally effective in its results and simple in its execution.

A similar use of the Kirschner wire is advocated by Suire and Thobois for the primary treatment of fractures of the clavicle. This bone differs from other long bones in that there is a relatively short medullary canal, the rest of the bone having a cancellous centre which may well lead the operator into some difficulty. Most argument about the technique has centred on whether or not an incision is necessary for the insertion of the wire, or whether it can be just as efficiently introduced subcutaneously. The present authors decide definitely for an open incision uncovering the fracture site, for the following reasons. The clavicle cannot be shown in X-ray films in various planes; the displacement of the fragments is often very great and very difficult to reduce; detached fragments often complicate the position; and it is particularly necessary to avoid damage to the large vessels at the base of the neck.

They therefore make an incision which will expose the site of the fracture, and they introduce the wire according to the position of the break. For fractures of the outer third the displacement is entirely of the inner fragment, and therefore the wire is inserted first into the outer fragment, its direction being carefully judged so that it will, on entering the inner fragment, traverse its whole length and not emerge through the posterior border among the neck structures. In fractures of the middle third the outer fragment is pulled downwards and backwards, and the first insertion is therefore into the inner fragment, although the outer can be used if need be. If the fracture is in the inner third, entry by way of the inner fragment would endanger the sterno-clavicular joint, and in this case entry is made through the outer fragment, the wire coming out through the anterior surface of the bone and the skin before being reversed into the inner fragment.

Once the wire is in place and the wound closed, elbow and shoulder movements are permitted from the second post-operative day, and the wire is left in place for twenty-five days. Fractures so treated are in the authors' opinion rather slower to consolidate than those treated by the more usual methods, and this fact must be taken into account when the after-treatment is planned.

ARTHUR E. BROWN.

THE USE OF PARATHYREOID GRAFTS IN POST-OPERATIVE TETANY.

R. Peycelon and C. Guillemin: *"Tetanie parathyreoprive. Greffe de parathyroide prélevée sur un malade atteint de maladie osseuse de Recklinghausen", Lyon chirurgical,* Volume xli, 1946, page 690.

THE results obtained by parathyreoid grafting in cases of tetany following operative removal of the thyreoid have been on the whole disappointing and have in fact led to the wide use of other methods of therapy—the use of calcium, of ergosterol and its derivatives, and of such special substances as Holz's "AT 10". While the value of these is not denied, especially in cases of lesser gravity, they can hardly be considered as other than modes of alleviation in the more severe cases; whereas the graft, if successful, is a definite cure and should not be allowed to fall into disuse.

Previous reports on parathyreoid grafting, in the French literature, from Morel in 1912 to Bérard and Henry in 1936, indicate that 50% of patients may be classed as cured and 25% as improved only, 25% of cases being frank failures. It is very difficult to form an accurate judgement on these reports. They include all grades of severity of the disease—acute, subacute and chronic—in which the outlook varies greatly. Further, the essential step of histological identification of the actual gland transplanted has generally been omitted. Many cases of post-operative tetany go on to spontaneous cure, the loss of parathyreoid secretion being only temporary and due to hæmorrhage, trauma *et cetera*, rather than permanent and due to ablation of the secreting gland itself. Whether the graft is heterogenous, autogenous or homogenous, as is the one referred to in this case report, the conditions for success must include these: it must be transplanted with the minimum of delay and if possible without passing through containers; the trauma associated with the removal and implantation of the glandule must be minimal; and hæmostasis must be absolute. There was an additional circumstance of interest in the present case, in that the engrafted glandule was taken from a subject suffering from Recklinghausen's cystic disease of the bones, and was therefore presumably in a hyperactive state.

Opinions have differed considerably about the optimum time at which the operation should be performed. Theoretically, of course, it should be done as soon as the symptoms are manifested. But a period of medical treatment is wise, since it may in itself prove that further surgical treatment is unnecessary. Also it is the opinion of many that there is a delay of some weeks between the implantation of the graft and the evidence of its effects, which interval itself will require efficient medical tratment. But some cases reported by Pool throw doubt on this supposition. In one of those patients the tetanic symptoms disappeared entirely in two days after the subperitoneal implantation of a homogenous graft. In the case here recorded a striking change occurred on the second day, and all medical treatment was permanently discontinued on the third. This case, although too recent for a long-term report, illustrates the brilliant results which may follow a successful graft.

The patient was a woman, aged sixty-three years, who underwent a thyreoidectomy in January, 1946. Five days later tetany supervened and it became rapidly worse until on her admission to hospital in Lyons she presented as grave a picture of tetany as is conceivable. Motor hyperexcitability was intense. The upper limbs were rigid and spasms occurred with distressing frequency. Trousseau's and Chvostek's signs were strongly present. The patient presented a picture of severe toxæmia and psychical deterioration. She lay inert, emaciated, with retention of urine and overflow emptying of the bladder, stuporose and unresponsive, and unable to feed herself, while trophic changes were apparent in her fingernails. Intensive intravenous medication with calcium and "Sterogyl" brought some ease, and she became able to feed herself and to drink. Her blood calcium content was 0·85 milligramme *per centum*.

At this time there was in the hospital a young man, aged twenty-one years, who was suffering from Recklinghausen's disease, whose blood calcium content was 110 milligrammes *per centum*, whose blood phosphorus content was 40 milligrammes, and whose blood phosphatase activity represented 40 Roberts units, though no parathyreoid adenoma was palpable in his neck. On May 31, 1946, the two patients were taken to the operating theatre and laid on neighbouring tables. Search was then made of the man's thyreoid region for a parathyreoid tumour. None was found, but from the right side two small nodules of probable parathyreoid tissue were removed, while on the left side there was found behind the thyreoid a yellowish body, 1·0 centimetre in length and a few millimetres wide, which was removed. A portion of this was later

proved histologically to be parathyreoid tissue. This body was immediately implanted into the left sterno-mastoid muscle of the female patient, the two doubtful nodules being similarly implanted into the right.

The results were most gratifying. Contracture and rigidity disappeared on the second post-operative day, the patient being able to move her arms with ease and to use her fingers, while all spasm ceased at once. The next day all medical treatment was discontinued and has never since been renewed. The patient began to eat, with good appetite, got up, walked, slept well and became happy and responsive. Her bladder functions became normal, and shortly she went to her home a normal, happy woman. The last news from her is that this pleasant state has been maintained. Later results of the operation for the donor are not given, but it is stated that he has not shown any symptoms of tetany due to the loss of parathyreoid tissue.

So good a result in so severe a case of *tetania parathyreopriva* must turn one's mind again to the possibilities offered by parathyreoid grafting. It is not necessary in conditions of minor severity with modern medical methods of treatment. But in desperate cases it offers a hope of permanent cure which no series of repeated injections could possibly parallel.

ARTHUR E. BROWN.

Review.

Textbook of Surgical Treatment, Including Operative Surgery. Edited by C. F. W. ILLINGWORTH, C.B.E., M.D., Ch.M., F.R.C.S.E.; Third Edition; 1947. Edinburgh: E. and S. Livingstone. 9¼″ × 5¾″, pp. 656. Price: 32s. 6d. (Sterling) net.

THIS book in its third edition is increased in size by 80 pages, and 59 new illustrations have been added. Certain chapters have been rewritten or added; for example, that on "Wounds and Wound Infections" has been rewritten by Professor Aird; a chapter on "Penicillin in Surgery" has been added by Mr. I. G. Macadam; a new chapter on "Plastic Surgery", written by Mr. A. B. Wallace, appears. Mr. T. Gibson has contributed a new section on "Facio-Maxillary Injuries", and a most valuable chapter on "Rehabilitation", arising from experiences of the recent war, has been prepared by Mr. R. Barnes. Certain other chapters have been elaborated and material representing the many advances in the craft of surgery during the past three years has been included, notably upon the use of protein in surgery, upon the significance of the Rh factor, and on the anticoagulant treatment of thrombosis.

The book, as in the previous editions, presents a series of accounts of the treatment of various surgical conditions, and it approaches the subject of surgical treatment in a manner different from that of most operative surgery textbooks. Fuller accounts of pre-operative and post-operative treatment are given and, as the editor writes: "While descriptions of operative technique are included, they have been given their proper place in a scheme which includes all forms of surgical care."

The book is a most valuable one and is commended to all senior students and those undergoing surgical apprenticeship.

Proceedings of the Royal Australasian College of Surgeons.

GORDON CRAIG LIBRARY.

EACH Fellow of the College has received a copy of the Library Catalogue, which includes all material housed in the library at June 30, 1947. Between dates of publication of the catalogue additions to the library will be announced in the journal.

The following is a classified list of new material added to the library since the date on which the catalogue was published.

Periodicals, Transactions et cetera.

Annals of the Royal College of Surgeons of England, 1947.
British Journal of Cancer, Volume i (1947).
Medical Bookman, 1947.
Ophthalmic Literature, 1947.
Overseas Post-graduate Medical Journal, Volume i (1946).

Textbooks and Monographs.

Anæsthesia.

British Medical Association (Tasmanian Branch): "Centenary of the Introduction of Surgical Anæsthesia to Australia", 1947.

Finsterer, Hans: "*Methoden der Lokalanästhesie in der Bauchchirurgie und ihre Erfolge*", 1923.

Kern, Ernest: "*L'anesthésie intraveineuse au pentothal-sodium*", 1946.

Anatomy, Embryology and Histology.

Beesly, Lewis, and T. B. Johnston: "Manual of Surgical Anatomy", 1916.

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Percival, G. H., A. Murray Drennan and T. C. Dodds: "Atlas of Histopathology of the Skin", 1947.

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Curtis, Arthur Hale: "Textbook of Gynecology", Fifth Edition, 1947.

DeLee, Joseph B., and J. P. Greenhill: "Principles and Practice of Obstetrics", Ninth Edition, 1947.

Mayes, Bruce T.: "Practical Obstetrics", 1947.

TeLinde, Richard: "Operative Gynecology", 1946.

Historical Section.

(Including History of Medicine, Biographies *et cetera*. Books published before 1850 are included in this section.)

Duncan, Alexander: "Memorials of the Faculty of Physicians and Surgeons of Glasgow, 1599-1850", 1896.

Fulton, John F.: "Harvey Cushing; A Biography", 1946.

Gairdner, John: "Historical Sketch of the Royal College of Surgeons of Edinburgh", 1860.

Gibson, Tho: "Anatomy of Humane Bodies Epitomized", Second Edition, 1684.

Stevenson, R. Scott: "Morell Mackenzie: The Story of a Victorian Tragedy", 1946.

Medicine.

Brunton, Sir Lauder: "On Disorders of Assimilation, Digestion etc.", 1901.

Cox, Leonard B., and J. C. Tolhurst: "Human Torulosis: A Clinical, Pathological and Microbiological Study with Report of 13 Cases", 1946.

(Barell, Emil): Jubilee volume dedicated to Emil Christoph Barell, 1946.

Feinberg, Samuel: "Allergy in Practice", Second Edition, 1946.

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Macy (Josiah Macy Jr. Foundation): "Conferences on Liver Injury" (first-fifth meetings), 1943-1946.

Reifenstein, Edward C., junior (editor): "Conference on Metabolic Aspects of Convalescence" (transactions of thirteenth and fourteenth meetings), 1946.

Samuels, Jules: "*Die hormonalen Aspekte des Fortpflanzungsprozesses*", 1946.

Trousseau, A.: "Lectures on Clinical Medicine", five volumes, 1868-1872.

Walshe, F. M. R.: "Diseases of the Nervous System", Fifth Edition, 1947.

Walshe, F. M. R.: "Contribution of Clinical Study to the Physiology of the Cerebral Motor Cortex", 1947.

Warkentin, John, and Jack D. Lange: "Physician's Handbook", Fourth Edition, 1946.

Miscellaneous.

Grober, J.: "*Das deutsche Krankenhaus*", Second Edition, 1922.

Zeta: "Acute Abdomen in Rhyme", 1947.

Ophthalmology.

Stallard, H. B.: "Eye Surgery", 1947.

Pathology—General and Special.

(Including Tuberculosis, Tumours *et cetera.*)

Boyd, William: "Surgical Pathology", Sixth Edition, 1947.
Dew, Harold: "Malignant Disease of the Testicle: Its Pathology, Diagnosis and Treatment", 1925.
Ghon, Anthon: "Primary Lung Focus of Tuberculosis in Children", 1916.
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Radium, Radiology.

Cohn, Toby: "*Leitfaden Elektrodiagnostik und Elektrotherapie für Praktiker und Studierende*", 1902.
Leborgne, Raul: "*Estudio radiologica del sistema canalicular de la glandule mamaria normal y patologica*", 1943.

Surgery.

(i) General—

Bernheim, Bertram M.: "Surgery of the Vascular System", 1913.
Brehant, J.: "*Chirurgien en présence de l'état diabétique*", 1946.
Christopher, F.: "Textbook of Surgery", Fourth Edition, 1946.
Iselin, Marc: "*Chirurgie de la main*", Fourth Edition, 1946.
Nordenson, Nils Goran: "Studies on Bone Marrow from Sternal Puncture", 1935.
Paterson, Herbert J.: "Surgery of the Stomach: Handbook of Diagnosis and Treatment", new edition, 1914.
Spiesman, Manuel G.: "Essentials of Clinical Proctology", 1946.
Strominger, L.: "*Appendicite et urologie, étude médico-chirurgicale, clinique et thérapeutique*", 1946.
Wilson, James V.: "Pathology of Traumatic Injury: A General Review", 1946.

(ii) Neurosurgery—

Great Britain, Board of Control (England and Wales): "Pre-Frontal Leucotomy in a Thousand Cases", 1947.

(iii) Operative—

Gould, Alfred H.: "Technic of Operations upon the Intestines and Stomach", 1906.
Spivack, Julius L.: "Surgical Technic of Abdominal Operations", Fourth Edition, 1946.

(iv) Orthopædic—

American Academy of Orthopædic Surgeons: "Lectures on Regional Orthopædic Surgery and Fundamental Orthopædic Problems" (edited by James E. M. Thomson), 1947.
Fishbein, Morris (editor): "Bibliography of Infantile Paralysis with Selected Abstracts and Annotations, 1789-1944", 1946.
Graham, Douglas: "Massage: Manual Treatment, Remedial Movements", Fourth Edition, 1913.
Hoffa, Albert: "*Lehrbuch der orthopädischen Chirurgie*", Fourth Edition, 1902.
Ivy, Robert H., and Lawrence Curtis: "Fractures of the Jaws", Third Edition, 1945.
Wijnen, H. P.: "*De behandeling van beenbreuken met het uitgebalanceerde zweefrek-verband*", 1927.

War Medicine and Surgery.

Wright, David G.: "Observations on Combat Flying Personnel", 1945.

The attention of Fellows is particularly directed to the services which can be rendered to them from the Gordon Craig Library. These are set out hereunder in the Regulations. The College is particularly anxious to be of assistance to Fellows resident in States other than Victoria and in New Zealand.

1. Fellows of the College and Fellows and Members of The Royal Australasian College of Physicians may receive on loan any textbook, monograph, journal or reprint available at the College, with the exception that books published prior to 1850 are not available on loan.

2. Those resident in the Commonwealth of Australia will not be permitted to retain a book for more than one month, and those resident in the Dominion of New Zealand for more than two months.

3. Books not returned at the expiration of this time will be charged to borrowers.

4. No one will be permitted to borrow more than two books or two journals, or one book and one journal, at one time without special permission.

5. On production of a card of introduction signed by a Fellow of the College, members of the medical profession may use the library for reference purposes and for reading.

6. Translations from foreign journals received in the library will be supplied to Fellows of the College. If the cost does not exceed £10 in any one year, half will be paid by the College and half by the Fellow. Any cost in excess of £10 will be paid by the Fellow. The Executive Committee may vary this regulation in special cases and on application.

7. Photostatic copies of articles and illustrations appearing in textbooks, monographs, medical and surgical journals received at the College will be supplied to Fellows free of charge. These photostats are supplied on loan and must be returned to the library.

8. Lists of references will be supplied to Fellows of the College who are writing papers. Information concerning articles published on any particular subject, or by any particular author, will be supplied. Should the journal required not be obtainable in the College library, facilities are available whereby Fellows may be informed whether the journal they require is available in Australia and, if so, at which library.

Books Received.

"An Introduction to Gastro-Enterology". By James Dunlop Lickley, M.D.; 1947. Bristol: John Wright and Sons, Limited. 7″ × 4¾″, pp. 150, with 21 figures. Price: 8s. 6d. (Sterling) net.

"A Complete Outline of Fractures, Including Fractures of the Skull". By J. Grant Bonnin, M.B., B.S. (Melbourne), F.R.C.S. (England); Second Edition; 1946. London: William Heinemann (Medical Books), Limited. 8½″ × 5¼″, pp. 672, with 693 figures. Price: 30s. (Sterling) net.

"Radium Dosage—The Manchester System". Edited by W. J. Meredith, M.Sc., F.Inst.P.; 1947. Edinburgh: E. and S. Livingstone, Limited. 9¾″ × 7″, pp. 134, with 38 illustrations. Price: 15s. (Sterling) net.

"*Die hormonalen Aspekte des Fortpflanzungs*". By Dr. Jules Samuels; 1946. Amsterdam: Holdert and Company, N.V. 9½″ × 6″, pp. 152.

Obituary.

SIR ALEXANDER MacCORMICK.[1]

WE are indebted to Dr. Robert Scot Skirving, of Sydney, for the following appreciation of the late Sir Alexander MacCormick and his influence on surgery in Australasia.

In considering the careers of distinguished medical men, it is not easy, especially when the subjects of such a survey are happily still with us, to fully and justly assess the ways in which their life's work has influenced the knowledge and practice of their profession. It is indeed doubly difficult to the writer of this paper, for he must not allow himself to be biased by the false balance of friendship, and thereby be too blind to faults, or to overstress virtues. Moreover, in medicine a great deal depends on whether the man in question made his learning and skill known to a wide circle by speech or writing.

There are many instances where the influence of the individual has been amplified in varied directions by the lectures he gave or the books he wrote. Such gifts are not very uncommon and to their use we owe much book knowledge—sometimes of real value.

To the radiant few their influence is by discovery—they worked, often for years, they incubated silently, and, at long last, delivered themselves, perhaps of a new

[1] This appreciation was written by request some time before MacCormick's death. It has not been altered.

evangel, such as Lister gave to the world and made unborn generations his debtors. Such bright stars come rarely into this troubled and dishevelled world. But there are others, happily not very uncommon, who shine with a lesser light, but when the daily work of this admirable band is witnessed to the profit of their immediate colleagues, there are found, here and there, in many lands, a few who, without the great assets of words and writing, have profoundly influenced those who had the good

fortune to see them at work—in our profession, in the ward, at the bedside, in the theatre, in the pathological departments and laboratories where these men toiled terribly.

Of this admirable and small company Alexander MacCormick was a marked and unforgettable example in teaching by his deeds and obvious wisdom. I have occasionally been a little peeved when some young doctor, who had qualified after MacCormick had given up his strenuous labours, has asked me the question: "What record of his work remains in print, and what specially did he do?" I sometimes, if I liked the questioner, tried to explain that, although MacCormick described no new diseases and so perpetuated his name, yet he taught visually endless important improvements in technique and by his methods brought the relative importance of apparently contrary signs and symptoms into their proper perspective in diagnosis.

Well, I admit he did not do much writing—more's the pity! I fear he certainly did not commit his experience to cold print, but he taught by example how best to do things as few men have done so well.

Those who were his residents or, more fortunate still, his assistants, will bear me out in admitting that he formed their minds and taught them to practise their profession with restraint, sanity and skill.

Alexander MacCormick was markedly a Celt. He was born in Argyllshire, I think in 1856, and came of good old country stock, from whom he inherited many cardinal virtues, and also a few prejudices, in which I heartily shared. He also possessed a strong constitution and the ability and determination to master whatever he undertook. He knew about country things, and from his childhood he had a love for the sea and "little ships". The imprints of the moorland, "the misty island", and the nearby Atlantic etched themselves into his thoughts and actions, and so he always remained in heart a son of that dear western coast, with its lochs and bens, its isles and kyles, where "they speak the Gaelic tongue".

I have forgotten where he went to school; my knowledge of him only came when I was his fellow student in Edinburgh. He was a good, steady worker, but I cannot recollect any academic honours obtained by him as an undergraduate. I remember sitting in class behind him and Arthur Conan Doyle and, after my usual unpleasant fashion, wondering what would be the after-fates of these two hefty fellows, who did not then greatly impress me. But Doyle created Sherlock Holmes, modelled from Joseph Bell, with his shrewd, uncanny deductions from small observed points, and MacCormick became one of the very best exponents of safe surgery. In spite of all authoritative statements to the contrary, Doyle did get his ideas of Sherlock Holmes from the wonderful out-patients' clinic of our common master Joseph Bell.

MacCormick did not hold any of the resident posts in the Royal Infirmary in Edinburgh, but went to Liverpool and became resident to Bickersteth, one of the best provincial surgeons in England. The influence of his chief was great, lasting and beneficial, and so he was not unlucky in not getting on at the Royal in Edinburgh, but rather the reverse.

I think that about this time he went on a voyage or two to America as surgeon in a steamer. I know he visited Boston, for I remember his interest in an anatomical teacher there demonstrating the inflation of the lesser sac of the peritoneum through the foramen of Winslow and pointing out that the fenestration of the lesser omentum is not the same in infancy and adult life. MacCormick was always a keen anatomist and that was a dominant factor in his surgical success.

I think he graduated in 1880 and arrived in Sydney in 1883 to be demonstrator of anatomy in the infant school of medicine just then taking shape under the impetuous urgence of Anderson Stuart.

I am sure he taught practical anatomy with infinite pains to his fortunate small bunch of students, and, at the same time, he gained for himself that instant useful knowledge of the human body which made him so sure and swift in his operative work.

About this time he wrote a thesis on the musculature of the native cat for his M.D. degree, for which he was awarded a gold medal.

MacCormick, let me repeat, was first and last a surgeon-anatomist, as was my master James Spence, whom MacCormick greatly admired.

Time passed and the day came when he took the cold plunge into practice in Macquarie Street, and he helped to fill the lean stock-pot of these early years by attending to the children in the Randwick institution and lecturing on *materia medica*. These small lapses from the narrow way of surgical purity may be forgiven him. They certainly did him no harm and may have helped to make him a real all-round doctor in the best and widest sense, though, in moments of misjudgement of himself, he would deny being so.

But success in his own chosen field was soon over the horizon. One or two medical men in large practice in Sydney had the insight to see that they had found a star, and the good sense to employ him to do some of their operative work. I rather fancy that wiring the olecranon was one of the earliest operations he did in private practice. Then he was appointed an assistant surgeon to the Royal Prince Alfred Hospital.

He seemed to me at that time singularly unambitious, at least outwardly. I remember him saying that if he had the charge of a moderate number of beds and earned a few hundred a year he would be satisfied. I wondered! Well, that phase must have soon passed, for, in a very short time his argosy was well afloat with a fair wind blowing and bringing him to a huge practice and the deserved confidence of the profession and the public, and these he held unsurpassed for all the years of active life.

He served his complete term of office in the Royal Prince Alfred Hospital and was at times on the staffs of the Sydney, Saint Vincent's, and Prince Henry Hospitals.

I doubt if any one surgeon in Australasia was ever more actively or successfully employed in consulting and operative work, and he did it all with such wholehearted vigour and unfailing honesty.

I remember sitting at dinner next to one of the leaders of American surgery and listening to his remark about MacCormick: "I have seen", said he, "many of the best operators in North America, Great Britain and a few in other lands. Here and there I recognize that some specialist may do, say, a goitre, a brain tumour, or some tricky urological operation, quicker, possibly a little better, than your MacCormick, but generally, from the scalp to the heel I've never seen his equal for sureness, safety and even speed." High praise from such a man, but not undeserved.

As a consultant he was admirable and full of help when there was just one other doctor to meet him, but, I must admit, when fussy friends, thinking that "in the multitude of counsellors there is wisdom" (safety is the correct rendering of the text), insisted on a plurality of advisers, he was not at his best; he lost interest I think, and even perhaps drifted in letting courses be taken which, in his heart, I am sure he did not wholly approve. This is just another example of divided responsibility where the best is not always done by boards and committees. Too many consultants are a mistake—Charles II suffered from nineteen, and I understand died under their treatment.

MacCormick did not love congresses and medical meetings—he kept away from them and seldom contributed anything to them. This was a pity, for if he had contributed something one may be sure it would have contained practical experience and common sense. I am afraid he avoided also all public positions, such as a senator in the university, or being president of the congresses in Australia, which I well know he could have occupied.

It was a joy to see him at work, removing a breast, a jaw and tongue, a complicated gastric or biliary operation, or, best of all, a difficult dissection of the gland-bearing area in the neck. All done with modesty and speed, without any of that sort of theatrical flourish sometimes adopted by smaller folk with a hankering after operative glory. Such epiphytic capers always make me ready to spit blood.

But with MacCormick there was a real artistry in every turn of his wrist or movement of his deft fingers, which, indeed, were sturdy digits, not a bit like the surgical fingers described by lady novelists. He just seemed to caress the tissues and, I think, gave confidence to many young aspirants for operative fame; but what looked so easy and safe in the hands of this master, was sometimes imitated by others with neither the care nor the safety of their exemplar. Nevertheless his influence was profound and beneficial; so from the wards and theatres in the hospitals in which he served went forth a new concept of surgical methods, a higher standard of work, and a real desire "to practise a divine art not frivolously".

I think hospitals have a soul as well as a body. It is not alone the bricks and mortar which count, but rather the soul—that is the work done and the success achieved by their staffs.

Early in 1900 MacCormick went to the South African War as a consulting surgeon.

Well do I recollect the somewhat useless period spent over this campaign. However, some of us most properly thought it our duty to go there, so we went.

From 1901 on, MacCormick just worked as few men have had the strength to do, with unabated vigour and usefulness. Then came the real testing time to our nation—and again he went overseas, but I fear that once more his special talents never found a fitting sphere for their exercise; but he did his duty and was both in France and the Near East.

In common with thousands he suffered a grievous loss in the death of his eldest son in action in France. He was a young officer in that very proper regiment for his father's son—the Argyll and Sutherland Highlanders. This loss was endured with that decorous fortitude which was part of this man's make-up.

I do not consider that he could ever have been at his best in war surgery. He hated pus and wounds other than those made by his own deft hands—nor were the problems of war injuries of the kind which his uncanny extra sense seemed to some of us to lead to clarity when much else to help the diagnosis was confused or obscure.

In his early formative and also in his pressing years of work I fear he had little time for general reading, but he must have made time for some professional study.

Nor had he leisure for most amusements. He hated games with balls—I like him for that; but he had one real interest—a true passion for the sea was in his blood and he loved it, and little ships too, and again I liked him for so doing. I remember we both began our yachting in Sydney by buying Chinese canoes—great fun when the rose of youth was still upon us. Then he had a "Mersey canoe"—a two-sticker and no bad little craft; but as he got older he liked something bigger, "with a lid on it"—that is, a deck—and he owned several fine craft. One, the *Ada*, a schooner, built by Fife of Fairlie, he sailed out from Scotland, when about seventy—no mean performance for a man of his years; but he never wrote a line about that passage.

I used to think what a fine captain of a China clipper he would have made, racing home from The Pagoda anchorage with the first teas of the season. But I am

not so sure that I would have enjoyed being one of his crew, for I fancy I would have found him too exigent.

Well, the years passed for him in unbroken professional prosperity, but a time came when he considered he should coil up his ropes and make a finish. There are two ways of bringing one's life's work to an end: "by crisis"—just taking down one's plate and going—or "by lysis", and so gradually fading into desuetude. With MacCormick the first method only was suitable.

His "kenotic" kind of work was best ended abruptly, and so he ceased to practise and went home—to Jersey. For him to drop the full life right off was not a wrong way of retiring; he always said he would not stay in harness and find the weight of years stiffening his fingers or his judgement and seeing patients leave him and not himself doing so.

I remember quoting Bacon's words, which I here righteously print with inverted commas, though I know several lesser persons have said the same thing: "Who can see worse days than he, that yet living, doth follow at the funeral of his own reputation?" But he would have none of such slow professional deaths, and so he left Australia.

I think the troubled later years, when he was hunted out of the Channel Islands, must have been a long-drawn Calvary to a man of his temperament—hungry for rest and peace.

Some people used to say he had little sense of humour. This was not quite true. He had little liking for certain sorts of agile wit and failed to pick up smart, flippant English fun; but he had a quite fine pawkey dry humour of his own. One morning he came into my room and said: "Come over with me, I want you to tell me what you think about an old countryman of ours; it will only take you a few minutes." I went. After I had told MacCormick what I thought about the case, the patient said: "Sir Alexander, how much will I give the doctor here?" "Two guineas", said A.M. The patient with some small difficulty extracted from a hidden place in his underclothing anterior to Scarpa's triangle two warm and crumpled notes. A little awkward pause ensued. Nothing happened. The patient looked doubtfully about and, seeing MacCormick in a rather curious attitude, said: "Sir Alexander, what are you looking for beneath that table?" "For those two shillings you owe the doctor!" No one smiled. The consultation ended agreeably. We three Scotsmen understood each other thoroughly and we parted with expressions of mutual esteem.

Before he finally left Australia he certainly tried to satisfy all those obligations which a man of his type would wish to do.

I have heard of people who wickedly said he was "unduly Scotch". But they did not know that his left hand many times did not learn what his right had done.

He gave "The Terraces" (now "The Scottish Hospital"), his own private hospital, to the public, and other generous things which were perhaps never heard about, and, better still, he left behind a reputation which the best of us may justly envy. Not only with those of his own profession who knew him, but among countless patients whose lives had been saved or made happier by his skill in that art and craft which he had practised so brilliantly for about fifty years.

If this small appreciation, written by one who, I suppose, must be about the last of his fellow students, does anything to impress those of a younger vintage, who knew him not, that we really possessed in him a truly great practical surgeon, I shall count myself fortunate in having written it.